HEALTH-CARE WASTE MANAGEMENT OF THE HOSPITALS IN THE EUROPEAN SIDE OF ISTANBUL

by

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ABSTRACT

The inefficient management and disposal of the health-care wastes generated at the health-care institutions is the significant problems faced in the İstanbul City of Turkey. This study will refer to the development of an integrated health-care waste management plan at the European Side of İstanbul City.

In the scope of the study, firstly the existing institutional and legislative framework are reviewed and the health-care institutions generating the wastes are surveyed through the prepared questionnaires, comprehensive field research and personnel interviews. By the obtained data, the inventory about the amounts, types and sources of the health-care wastes is developed. The infectious composition of the health-care wastes is also determined by the conducted microbiological analyses.

To analyze the possible cost reductions, the optimum waste prevention and minimization techniques are suggested for the health-care institutions. For the problem of the transportation and disposal of these wastes; the optimum transportation routes are prepared and the appropriate treatment and disposal technologies are determined.

The final stage is planning and proposing a health-care waste management center which can be used as a basis for the other cities in Turkey. All the graphs, tables and maps related to the proposed suggestions are illustrated in the study.

ÖZET

İstanbul'da karşılaşılan en önemli sorunlardan biri de, sağlık kuruluşlarında kaynaklanan tıbbi atıkların hatalı yönetim ve bertaraflarıdır. Bu çalışma, İstanbul Avrupa Yakası'nda yer alan sağlık kuruluşları için bir entegre tıbbi atık yönetim planı geliştirilmesine ilişkin konuları kapsamaktadır.

Çalışma kapsamında, öncelikle mevcut yasal ve kurumsal düzenlemeler değerlendirilmiş, tıbbi atıkların kaynaklandığı sağlık kuruluşları hazırlanan anketler, yetkililerle yapılan mülakatlar ve kapsamlı bir saha çalışması yardımı ile incelenmiştir. Elde edilen veriler, tıbbi atıkların miktar, tür ve kaynaklarına ilişkin bir envanter geliştirilmesinde kullanılmıştır. Tıbbi atıkların bulaşıcı nitelikteki kompozisyonları, gerçekleştirilen mikrobiyolojik analizlerle tespit edilmiştir.

Bir sonraki aşama olarak, tıbbi atıkların yönetiminden kaynaklanan maliyetlerin azaltılması amacı ile atık azaltılması ve önlenmesine ilişkin minimizasyon teknikleri belirlenmiştir. Tıbbi atıkların toplanma, taşınma ve nihai bertarafından kaynaklanan sorunlar için, mevcut sisteme alternatif olarak geliştirilen optimum taşıma güzergahları oluşturulmuş ve Avrupa Yakası için en uygun arıtma ve bertaraf sistemleri belirlenmiştir.

Son aşama olarak, Türkiye'de diğer şehirlere de temel olabilecek bir tıbbi atık yönetim merkezi geliştirilmiş ve önerilmiştir. Yapılan öneri ve yorumlara ilişkin tüm grafik, tablo ve haritalar çalışma içerisinde sunulmuştur.

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LIST OF SYMBOLS

CDC	Centers for Disease Control
EC	European Commission
EPA	Environmental Protection Agency
EU	European Union
FAO	Food and Agricultural Organization
HBV	Hepatit B
HCV	Hepatit C
HDV	Hepatit D
HIV	Human Immunodeficiency Virus
HPLC	High Performance Liquid Chromatography
ISTAÇ	Istanbul Metropolitan Municipality-Environmental Protection and Evaluation of Waste Materials Industrial and Trade Inc.
P	Pearson Value
PVC	Polyvinyl Chloride
S.I.I.	Social Insurance Institution
SPSS	Statistical Package for the Social Sciences
TSI	Turkish Standards Institute
UNCED	The United Nations Conference on the Environment and Development
WHO	World Health Organization
X^2	Chi-Square Test

1. INTRODUCTION

One type of hazardous wastes of particular public concern is health-care wastes arising from hospitals and other medical institutions. Hospitals and other health-care institutions have the responsibility of ensuring that there are no adverse health and environmental consequences on their handling, storage, treatment and disposal of health-care wastes. Being aimed at reducing the health problems and preventing risks to the health of people, health-care services inevitably generate wastes that may be hazardous to the health itself and are increasingly exposing patients, public, medical and support staff in health care establishments to avoidable health risks (Li and Jeng, 1993).

The management of health-care wastes in the country is driven by concerns about health and environmental effects, uncertainty regarding regulations, and the negative perceptions by waste handlers. Although significant progress has been made on health-care waste management, the studies indicated the need to introduce modifications to the existing healthcare waste management practices.

Some of the most common problems of the health-care wastes are identified as the inadequate waste management, lack of awareness about the health hazards, insufficient financial and human resources and poor control of health-care wastes. (WHO, 1999). The lack of the adequate collection and transportation methods, as well as of the appropriate treatment and disposal facilities may cause serious public health consequences and significant impact on the environment. The improper treatment of healthcare wastes in poorly designed and inadequately controlled incinerators cause the generation of a significant quantity of hazardous pollutants, such as dioxins and furans, HCl, and heavy metals including Cd, Hg, and Pb (Lerner, 1997). Since there is an increasing concern with hazards of health-care wastes, which has exploded recently and the wastes produced in the course of health-care activities carry a higher potential for infection and injury than any other type of wastes; the handling, storage, treatment and disposal of large volume of these hazardous wastes calls for effective management methods.

1.1. Purpose of the Study

The primary purpose of this research is to design of an Integrated Health-Care Waste Management Plan in the European Side of the city of İstanbul, in order to minimize the risks to human health and the environment and to bring Turkish legislation in compliance with the EU legislation and standards.

This study is designed for use by many different classifications of personnel within the health-care facilities, local government units and private service providers who are involved in the generation, handling, storage, treatment, and disposal of health-care wastes. The unit in-charge of health-care waste management is the first to become familiar with this study.

The study was conducted firstly to solve the problem of lack of reliable information concerning the quantities and types of health-care wastes and overcome the necessity for an effective inventory that would be used for the systematic registration of the data. The inappropriate institutional structure and the inefficient management of the resources that leaded to an insufficient management of the health-care wastes was aimed to be solved with the implementation of the institutional structure proposed in this study. The research also recommends efficient, sustainable and culturally acceptable methods for the transportation, treatment and disposal of health-care wastes, both within and outside health-care establishments. Both the health-care waste personnel awareness and public acceptance are taken into consideration in determining the appropriate technologies.

Through this research, health-care establishments will be able to install more efficient waste management systems that could provide benefits as the improved regulatory compliance, protection of human health by reducing the exposure on employees, patients, visitors, and entire community to hazardous health-care wastes and economic benefits resulting from the proposed technologies for the health-care waste management practices. The advice and guidance offered are intended to assist both national bodies and individual medical institutions to improve health-care waste management.

2. LITERATURE SURVEY

2.1. Definitions of the Health-Care Wastes

According to the Medical Wastes Control Regulation in Turkey, pathological and unpathological, infectious, chemical and pharmaceutical wastes, contaminated sharps and compacted containers generated by medical facilities and health-care institutions are considered as hospital wastes (Ministry of Environment and Forestry of Turkey, 1993).

In general, health-care wastes are also defined as "wastes generated by acts of diagnosis, follow-up and preventive, curative or alternative treatment, in the fields of human and veterinary medicine" (French Health Ministry, 1997). In the literature; health-care wastes are further classified as "all the wastes generated at the health-care establishments, research facilities and laboratories". It also includes the wastes originating from 'minor' or 'scattered' sources – such as the wastes produced in the course of health-care undertaken in the home" (WHO, 1999).

2.2. Classification of the Health-Care Wastes

Health-care facilities generate various kinds of wastes as a result of the variety of medical treatment and researches conducted. In the past 10 years, the generation rate of these wastes have increased rapidly due to the increased number and size of the health-care facilities, medical services and use of medical disposable products (Li and Jeng, 1993).

The generic term "health-care wastes" contains every hazardous and non-hazardous wastes generated by a health-care facility. The health-care wastes can mainly be classed as general, infectious, pathological, chemical, pharmaceutical, genotoxic and radioactive wastes, sharps, pressurized containers and as wastes with high content of heavy metals.

General wastes include all wastes that are not medical wastes and is not recyclable. This wastes are typically generated by the administrative or office components of a health-care organization and includes domestic type wastes, packing materials, non-infectious animal bedding, wastewater from laundries and other substances that do not pose a special handling problem or hazard to human health or environment (WHO, 1999).

Infectious wastes are suspected to contain pathogens in sufficient concentration or quantity to cause disease in susceptible hosts. Infectious wastes include all the medical wastes, which have the potential to transmit viral, bacterial or parasitic diseases. Infectious wastes are hazardous in nature and this category generally includes:

(a) cultures and stocks of infectious agents,

(b) wastes from surgery and autopsies on patients with infectious diseases (e.g. tissues, materials or equipment that have been in contact with blood or other body fluids),

(c) wastes from infected patients in isolation wards (e.g. excreta, dressings from infected or surgical wounds, clothes soiled with human blood or other body fluids),

(d) wastes that have been in contact with infected patients undergoing haemodialysis (e.g. dialysis equipment such as tubing and filters, disposable towels, gowns, aprons, gloves, and laboratory coats), and

(e) infected animals from laboratories (WHO, 1999).

Pathological wastes consists of tissues, organs and body parts and fluids, human fetuses and animal carcasses, products of conception and fluids removed by trauma or during surgery or autopsy or other medical procedure (WHO, 1999).

Chemical wastes comprise discarded solid, liquid, and gaseous chemicals. Chemical wastes from health-care institutions may be hazardous or non-hazardous. The hazardous chemical wastes likely found in the medical wastes are formaldehyde, phototographic chemicals, solvents, organic chemicals, laboratory reagents and disinfectants. For the purpose of choosing the most appropriate waste handling method, hazardous chemical wastes are considered to be waste that is: toxic, corrosive (acids of $pH < 2$ and bases of $pH > 12$), flammable, reactive (explosive, water-reactive, shock-sensitive) and genotoxic. Other than those described above, chemicals such as sugars, amino acids, and certain organic and inorganic salts are defined as non-hazardous chemical wastes (WHO, 1999).

Sharps are mainly used in animal or human patient care or treatment, in medical research, or industrial laboratories, including hypodermic needles, syringes, pasteur pipettes, scalpel blades, blood vials, needles with attached tubing and culture dishes (regardless of the presence of infectious agents). These wastes also include the other types of broken or unbroken glassware that were in contact with infectious agents, such as used slides and cover slips and any other items that could cause a cut or puncture (WHO, 1999).

Pharmaceutical wastes include expired, unused, spilt, and contaminated pharmaceutical products, drugs and chemicals that have been returned from wards, have been spilled, are outdated or contaminated, or are to be discarded. This category also includes discarded items used in the handling of pharmaceuticals, such as bottles or boxes with residues, gloves, masks, connecting tubing, and drug vials (WHO, 1999).

Pressurized containers include many types of gases often stored in pressurized cylinders, cartridges, and aerosol cans. Most common gases used in the health-care institutions are anesthetic gases, ethylene oxide, oxygen and compressed air (WHO, 1999).

Genotoxic wastes are highly hazardous and may have mutagenic, teratogenic, or carcinogenic properties. These wastes may include certain cytostatic drugs, vomit, urine, or faeces from patients treated with cytostatic drugs, chemicals, and radioactive materials. Cytotoxic drugs, the principal substances in this category, have the ability to stop the growth of certain living cells and are used in chemotherapy of cancer (WHO, 1999).

Wastes with a high heavy-metal content represent a subcategory of hazardous chemical wastes (mercury wastes typically generated by spillage from broken clinical equipment, blood-pressure gauges, etc.) and are usually highly toxic (WHO, 1999).

Radioactive wastes include wastes contaminated with radionuclides with short half-lives, which lose their activity relatively quickly, generated from in vitro analysis of body tissues and fluids, tumor localization and therapeutic procedures.

The classification of the health-care wastes is also summarized in Table 2.1 (KAKAD, 2003).

Table 2.1. Classification of health-care wastes (KAKAD, 2003)

Classification of the Health-Care Wastes				
Similar to Residential Wastes		Health-Care Wastes		
A: Recyclable Wastes	**B: Common Wastes**	**C: Infectious Wastes**	**D: Pathological Wastes**	**E: Other Dangerous Wastes**
All wastes reusable or recyclable generated within the health-care centre by administration, kitchen, warehouses, workshops etc. Its components are: (a) paper, (b) cardboard, (c) plastics, (d) glass, (e) metal, (f) not contaminated food wastes, (g) yard wastes, etc.	Some of these wastes require special management within the health-care center, outside they can be handled as common wastes. These comprise wastes derived from normal inpatient wards, outpatient examination rooms, first aid areas, administration, cleaning services, kitchens, stores and workshops. Its components are all wastes generated in the health-care centers with the exception of those listed in the groups A, C, D, and E, such as: (a) ash (b) bones (c) floor sweeping (d) packaging materials (e) newspapers (f) flowers (g) used bandages (h) other than recyclable materials.	Potentially infectious wastes that require special management inside and outside the health-care center, comprising: (a) all wastes from isolation wards, (b) wastes from clinical laboratories for micro-biological and infectious-serological investigations , (c) all wastes which constitute a real risk of infection when being disposed of, such as needles and sharp objects which are covered with blood or human secretion, (d) wastes from dialysis stations with risk to patients, (e) bacteria and virus retaining air filters.	This waste type requires special treatment, not only to prevent infections, but also for ethical reasons. This group comprises: (a) parts of human bodies generated in operating theatres, delivery rooms, morgues, autopsies, etc. Examples are organic tissues, placentas and amputated limbs, etc., (b) corps of animals used for biological experimentation, (c) blood and blood containers, (d) other body fluids from potentially infected patients.	This group covers waste types that, for legal reasons or because of their physical or chemical properties, require special management, such as: (a) radioactive wastes* (b) cytotoxics (c) chemical wastes (d) pharmaceutical wastes (e) other dangerous wastes. *radioactive material can only be handled by authorised personnel.

2.3. The Sources of the Health-Care Wastes

The diversity of the health-care industry is the main reason for the existence of many sources that may generate different quantities of medical wastes and the necessities of the different waste disposal methods. The sources of the health-care wastes can be classified as major and minor according to the quantities produced (WHO, 1999). The major sources of these wastes are given in Table 2.2 while the minor sources are listed in Table 2.3.

Table 2.2. Major sources of health-care wastes (WHO, 1999)

Major Sources of Health-Care Wastes
Hospitals (a) University hospitals (b) General hospitals (c) District hospitals
Other Health-Care Establishments (a) Emergency medical care services (b) Health-care centers and dispensaries (c) Obstetric and maternity clinics (d) Outpatient clinics (e) Dialysis centers (f) First-aid posts and sick bays (g) Long-term health-care establishments and hospices (h) Transfusion centers (i) Military medical services
Related Laboratories and Research Centers * (a) Medical and biomedical laboratories (b) Biotechnology laboratories and institutions (c) Medical research centers
Other Sources (a) Mortuary and autopsy centers (b) Animal research and testing (c) Blood banks and blood collection services (d) Nursing homes for the elderly

*Laboratories: mainly pathological (including some anatomical) produce highly infectious wastes (small pieces of tissue, microbiological cultures, stocks of infectious agents, infected animal carcasses and blood), sharps and some radioactive and chemical wastes.

Table 2.3. Minor sources of the health-care wastes (WHO, 1999)

Minor Sources of the Health-Care Wastes
Small Health-Care Establishments
(a) Physicians' offices (b) Dental clinics (c) Acupuncturists (d) Chiropractors
Specialized Healthcare Establishments and Institutions with Low Waste Generation
(a) Convalescent nursing homes (b) Psychiatric hospitals (c) Disabled persons' institutions
Non-healthcare Activities Involving Intravenous or Subcutaneous Interventions
(a) Cosmetic ear-piercing and tattoo parlous (b) Illicit drug users
Funeral Services
Ambulance Services
Home Treatment

The main units that use or produce health-care wastes in the major sources are bacteriology, clinical microbiology, hematology, human physiology, immunology, urinalysis, phlebotomy, and all dental hygiene and dental assisting clinical and laboratory courses.

While there is a large number of minor health-care wastes sources, such as physicians' offices, dentists' clinics, personal care units; minor and scattered sources generate health-care wastes similar to the hospital wastes but different in their composition. Minor sources rarely produce radioactive or cytostatic wastes. Human body parts are generally not included and sharps consist mainly of hypodermic needles. There are also support service sources that are pharmacy, laundry, kitchen, engineering, administration, and patient's attendance.

2.4. Composition and Characterization of the Health-Care Wastes

2.4.1. Composition of the Health-Care Wastes

The waste composition study is a part of continuing effort to measure and evaluate the waste generated in hospitals. The type of source often characterizes the composition of wastes. The different units within the major health-care establishment would generate different types of wastes. While medical wards, operating theatres, surgical wards and laboratories consist of the wastes including infectious wastes, contaminated gloves, contaminated packaging and disposable medical items, and certain body fluids; other units including the blood banks, pharmacy, kitchen, etc. comprise of mostly general wastes with small percentage of infectious wastes.

The composition of health-care wastes from the minor sources has also different composition. Physicians' offices and home health-care provided by nurses include general wastes, a limited amount of infectious wastes and some sharps like the small units in the hospitals. Dental clinics and dentists' offices include wastes with high heavy metal content in addition to the wastes described above (WHO, 1999).

In addition to the infectious wastes generated, health-care institutions also produce solid wastes considered as non-infectious (Table 2.4). In this table, paper, at 54 per cent, represents the highest percentage of the hospital solid waste stream. If significant reductions in the solid waste stream are to be achieved, these portions of the waste stream are the leading candidates for intervention strategies (Bisson *et al.*, 1993).

Table 2.4. Composition of a hospital solid waste stream (Bisson *et al.*, 1993)

Waste	**Weight (%)**
Paper	45
Organics (including yard wastes)	13
Plastics	15
Metals	10
Glass	7
Other (including disposable diapers)	10
Total	100

2.4.2. Characterization of the Health-Care Wastes

The calorific value, density and humidity values related to type of hospital wastes is given by Table 2.5. It should be taken into consideration that low calorific values hinder self burning of the wastes, on the other hand very high calorific values as it is sometimes with the hospital wastes are causing too much increase in temperature which may damage the incinerator. So that either the hospital wastes should be mixed up with other wastes with lower calorific values or the feeding capacity should be decreased so that not any damage to the incinerator takes place.

Table 2.5. Characterization of the health-care wastes (EPA, 1990; Kocasoy, 1995)

Waste Type	High Calorific Value (dry basis) (kJ/kg)	Bulk Density as Fired (kg/m^3)	Moisture Content (Weight %)	Heat Value as Fired (kJ/g)
Human bodies	18600-27900	800-1200	70-90	1860-8370
Plastics	32500-46500	80-2300	0-1	32300-46500
Absorbent pads	18800-27900	80-1000	0-30	13000-27900
Alcohols, disinfectants	25500-32500	800-1000	0-0.2	25500-32500
Infected animals	20900-37100	500-1300	60-90	2090-14900
Glass	0	2800-3600	0	0
Bedding, excrete	18600-20900	320-730	10-50	9300-18800
Paper	18600-27900	80-1000	0-30	13000-27900
Plastics, PVC, injectors	22500-46500	80-2300	0-1	22300-46500
Sharps, needles	140	7200-8000	0-1	140
Body liquids, wastes	0-23200	990-1010	80-100	0-4640

2.5. Generation of the Health-Care Wastes

Waste generation and quantity of health-care wastes depends on numerous factors such as established waste management methods, type of health-care establishment, hospital specializations, proportion of reusable items employed in the health-care institution, and proportion of the patients treated on a day-care basis. Generation of the health-care wastes differs not only from country to country but also within a country (Eren, 1996).

In the middle- and low-income countries, health-care waste generation is usually lower than in the high-income countries. However, the range of the values for countries of similar income level is probably as wide in high-income countries as in less wealthy countries. It also changes according to the definition of "infectious wastes". While some researchers accept only infectious wastes, others argue that all wastes, including the domestic wastes which are generated from hospitals must be considered as health-care wastes (Kocasoy, 1993).

Average distribution of the health-care wastes useful for preliminary planning of waste management can be given as follows:

(a) 80 per cent of the general health-care wastes, which may be dealt with by the normal domestic and urban waste management system,
(b) 15 per cent of the pathological and infectious wastes,
(c) one per cent sharps wastes, and
(d) three per cent chemical or pharmaceutical wastes (WHO, 1994).

Less than one per cent forms the special wastes such as radioactive or cytostatic wastes, pressurized containers, or broken thermometers and used batteries.

In order to determine the quantity of hospital wastes in Turkey, many surveys had been conducted. A systematic survey had been performed in 1990 in İzmir (Kocasoy, 1993). As a result of this survey, it was found that in 22 hospitals in İzmir area having a capacity of 8,168 beds, 2,700 kg of infected-hazardous wastes, 6,770 kg of wastes with domestic waste characteristics and 2,855 kg of office wastes have been produced daily.

Another study was performed in "S.I.I. Eyüp Hospital" in 1991 (İnceoğlu, 1991). According the data obtained, the average quantity of hospital wastes is 2.15 kg/patient/day.

The hospital waste generation rates in developing countries are relatively low compared with that in developed countries, which are typically in the range of 2-7 kg/patient/day. As the examples of different generation rates, the amount of hospital wastes generated in America is presented in Table 2.6 (Şan, 1991), while the wastes generated in Holland is given in Tables 2.7 (Rehan, 1993).

As it is concluded from the Tables 2.6 and 2.7, quantities of hospital wastes varies in a range of 1 kg/bed/day to 18 kg/bed/day. The differences between the countries are caused by the definition of infectious hospital wastes in different countries and development level of the countries.

Table 2.6. Hospital wastes in America (Şan, 1991)

Number of Bed	**Quantity of Waste**	
	Kg/Bed/Day	**Kg/Patient/Day**
<100	4.10	5.38
100-299	4.42	5.80
300-499	4.88	6.40
>500	5.24	6.87
Average	4.51	5.92

Table 2.7. Hospital wastes in Holland (Rehan, 1993)

Type of Waste	**Number of Bed**	**Quantity of Waste (kg/bed/day)**
Research clinics	900-1000	4.2
University hospitals	800-900	6.5
General hospitals	600-700	2.7
	300-400	2.3
Medical centers	<100	5.0
	100-200	6.0
Psychiatry hospitals	800-900	1.3
	400-500	1.2
Mental illness hospitals	400-500	1.8
	700-800	1.4
Elderly people's home	100-200	1.7

In Turkey, the number of hospitals and the number of beds in hospitals are increasing each year. Table 2.8 shows the treatment provided by in-patient institutions between the years 1986-1993 (State Institute of Statistics, 1994). According to The Ministry of Health Annual Report in 1997, 1120 hospitals are available in Turkey. It is estimated that the hospital wastes generated in the whole country are about 147 ton/day and the average amount of medical wastes per day per bed is around 0.66 kg (Demir *et al.*, 2002).

Table 2.8. Treatment provided by in-patient institutions (State Institute of Statistics, 1994)

	1986	1987	1988	1989	1990	1991	1992	1993
In-patients institutions	736	756	777	812	857	899	928	962
Number of beds	107,152	111,135	113,010	116,061	120,738	123,706	126,611	131,874
Persons under treatment (Total)	41,012,934	46,245,193	48,179,220	53,670,289	58,726,541	58,400,466	62,598,046	66,370,651
Out-patient	38,358,550	43,393,290	45,265,693	50,562,841	55,540,205	55,264,961	59,219,722	62,874,153
In-patient	2,654,384	2,851,803	2,913,527	3,107,448	3,186,336	3,135,505	3,378,324	3,496,498

Note: Military Hospitals are excluded.
Note that the number of beds per year 131,874 (in 1993 and the number of beds increasing every year) and daily 362 beds/day.

In İstanbul, which is the largest metropolitan city of Turkey with its 10 million populations, other than the hospitals relatively having no medical wastes and having 20 bed capacities, there are about 202 public and private hospitals with 33,095 bed capacity totally. Compared to other regions; 17 per cent of hospitals, 20 per cent of bed capacity, 54 per cent of private hospitals of Turkey are located in İstanbul. It is estimated that the hospital wastes generated in the whole country are about 147 ton/day and the average amount of medical wastes per day per bed is around 0.66 kg (Demir *et al.*, 2002).

2.6. Hazards and Infections Arisen from the Health-Care Wastes

The health impacts of direct and indirect exposure to health-care wastes include carcinogenic, mutagenic, and teratogenic effects, reproductive system damage, respiratory, central nervous system effects, and many others. The hazardous nature of health-care wastes can be due to the fact that it contains infectious agents, toxic or hazardous chemicals or pharmaceuticals or sharps, or it is radioactive, genotoxic, etc. (Appleton and Ali, 2000). Exposure to these wastes can result in diseases as mostly HIV (Human Immunodeficiency Virus), HBV (Hepatit B), HCV (Hepatit C) and HDV (Hepatit D) or injuries (Nessa, Quaiyum, Khuda, 2001).

A total of 80-85 per cent of the health-care wastes is classified as non-infectious or general wastes. It presents no higher risk to the community is considered to be non-hazardous. The remaining 10 per cent is infectious wastes, which could present a higher risk to the public and five per cent is regarded as other hazardous wastes (WHO, 1983).

Possible pathways include direct contact, contact through vectors, airborne transmission, and the pollution of water sources or local environment (Appleton and Ali, 2000). Further types of risks have been identified as perceived and actual risks, for example, some events, such as consequences of a needle stick injury posses both actual and perceived risk (Townend, 2002).

2.6.1. Main Groups of People at Risk

All individuals exposed to hazardous wastes are potentially at risk, including those affected through the direct contact with wastes every day of their working lives such as physicians, nurses, health-care personnel, and those outside the sources who either handle such wastes, or are exposed to it as a consequence of the improper management practices including the persons transporting these wastes, workers and operators of waste treatment and disposal facilities like the scavengers (WHO, 1999).

In addition to the health-care workers, waste handlers and landfill operators, the hazards of health-care wastes can become risks to also the population, which include patients and visitors in the health-care facility and general public living close to a waste dump and those, whose water supply has become contaminated either due to waste dumping or leakage from landfill sites, etc. (Salkin, 2002).

2.6.2. Exposure to Hazardous Health-Care Wastes

The presence of concentrated cultures of pathogens and contaminated sharps (particularly hypodermic needles) in the waste stream represents the most acute potential hazards to health. Sharps may not only cause cuts and punctures but also infect these wounds if they are contaminated with pathogens. Pathogens in infectious wastes may enter the human body by a number of routes like through a puncture, abrasion, or cut in the skin; through the mucous membrane; by inhalation; and by ingestion. Because of this double risk-of injury and disease transmission, sharps are considered as a very hazardous class.

For serious virus infections such as HIV/AIDS and Hepatitis B and C for which there is strong evidence of transmission via health-care wastes, health-care workers, particularly nurses, are at greatest risk of infection through injuries from contaminated sharps (largely hypodermic needles) (WHO, 1999). Preventing needle stick injuries and other potential exposures is likely to have the biggest impact on reducing HIV transmission in most of the hospital. The risk of this type of infection among patients and the public is much lower. Certain infections, however, spread through other media or caused by more resilient agents, may pose a significant risk to the general public and to patients (Morgan, 1999).

Although chemical and pharmaceutical products may be found in small quantities in health-care wastes, they may cause intoxication, either by acute or chronic exposure, and injuries, including burns. Intoxication can result from absorption of a chemical or pharmaceutical through the skin or the mucous membranes, or from inhalation or ingestion. Injuries to the skin, the eyes, or the mucous membranes of the airways can be caused by contact with flammable, corrosive, or reactive chemicals (e.g. formaldehyde and other volatile substances).

The most common injuries are burns. Disinfectants such as chlorine and sodium hypochloride are particularly important members of this group; they are used in large quantities and are often corrosive. It should be noted that reactive chemicals might form highly toxic secondary compounds (WHO, 1999).

Inhalation of dust or aerosols, absorption through the skin, ingestion of food accidentally contaminated with cytotoxic drugs, chemicals, or wastes and ingestion are the main pathways of exposure to genotoxic substances. The severity of the hazards also depends on the mode of exposure (inhalation, dermal contact, etc.). Many cytotoxic drugs are extremely irritating and have harmful local effects after direct contact with skin or eyes. They may also cause dizziness, nausea, headache, or dermatitis (WHO, 1999).

Radioactive wastes, mercury containing instruments (i.e., thermometers), and PVC plastics (which emit dioxin when burned) are among the most environmentally sensitive byproducts of the health-care wastes. Mercury attacks the central nervous system of the body; harms the brain, kidneys and limbs; and crosses the blood-brain barrier and placenta. Eating mercury in fish, meat, and dairy foods causes nervous system damage (Remy, 2001). Health effects caused by exposure to radioactive substances or materials contaminated with radioactivity can range from reddening of the skin and nausea to more serious problems such as cancer induction and genetic consequences to succeeding generations of the exposed individual (WHO, 1999).

2.6.3. Infections Arisen from the Health-Care Wastes

As the health-care wastes contain microorganisms putting the health of hospital personnel, and patients at risk, health-care wastes should be considered as a reservoir of pathogenic microorganisms which can cause contamination and give rise to infection.

Nosocomial infections, known also as hospital-associated infections, and hospital infections, are infections that are not present in the patient at the time of admission to hospital but develop during the course of the stay in hospital (Wenzel, 1997). Several studies conducted showed that nosocomial infections were grown on nearly 3.1-14.1 per cent of the patients treated in the hospitals. In the study carried in the U.S.A., 20,000 direct and 60,000 indirect death were faced relating to the two million nosocomial infections growth in the health-care institutions (Freeman and Mc Gowan, 1981). The general infection transmission rates depend on the size and the types of the institutions. While this rate is faster in the research hospitals, infections are transmitted gradually in the private hospitals (Horan *et al.*, 1986).

Healthy people are actually naturally contaminated. Faeces contain about 10^{13} bacteria per gram, and the number of microorganisms on skin varies between 100 and 10, 000 per cm^2. None of these tissues, however, is infected. Microorganisms that penetrate the skin or the mucous membrane barrier reach subcutaneous tissue, muscles, bones, and body cavities, which are normally sterile. If a general or local reaction to this contamination develops, with clinical symptoms, there is an infection.

The most important determinants of infection, however, are the nature and number of the contaminating organisms. Microorganisms range from the completely innocuous to the extremely pathogenic: the former will never cause an infection, even in immuno compromised individuals, while the latter will cause an infection in any case of contamination. A classification of conventional, conditional, and opportunistic pathogens is given in Table 2.9 (Parker, 1978).

Table 2.9. Classification of the pathogenic germs (Parker, 1978)

Classification	Examples
Conventional Pathogens: Cause disease in healthy individuals in the absence of specific immunity.	Staphylococcus aureus Streptococcus pyogenes Salmonella spp. Shigella spp. Corynebacterium diphtheriae Mycobacterium tuberculosis Bordetella pertussis Hepatitis A and B viruses Rubella virus, rotaviruses Human immunodeficiency virus (HIV)
Conditional Pathogens: Cause disease, only in persons with reduced resistance to infection (including newborn infants) or when implanted directly into tissue or a normally sterile body area	Streptococcus agalactiae Enterococcus spp. Clostridium tetani Escherichia coli Klebsiella spp. Serratia marcescens Acinetobacter baumanii Pseudomonas aeruginosa Candida spp.
Opportunistic Pathogens: Cause generalized disease, but only in patients with profoundly diminished resistance to infection.	A typical mycobacteria Nocardia asteroides Pneumocystis carinii

The main factors contributing to the spread of all these microorganisms in the air include poor sanitary conditions of hospital, over crowded wards, improper storage of health-care wastes and actual lack of any measures for their treatment (Kozlowska, 1993). If wastes are inadequately managed, these infections can be transmitted by direct contact, in the air, or by a variety of vectors. Therefore, it is essential to consider how improved segregation, handling, recycling and disposal of health-care wastes can lead to improved systems of management so that the hazards are controlled and the subsequent risks to people are reduced (Morgan, 1999).

2.6.4. Impacts of Health-Care Wastes on the Environment

Apart from the risk to the patients and health-care personnel, consideration must be given to the impact of health-care wastes on the general public through the contamination of the environment. In particular, attention should be paid to the possible pollution of the air, water and soil. With the direct contact of the health-care wastes, wastes can also contaminate the environment, such as the water or the air (the uncontrolled discharges of sewage from field hospitals treating cholera patients, emission arising from the burning of the health-care wastes, etc.), and so indirectly affect the public health (WHO, 1999). Mixing of infectious wastes with the others which are normally disposed along with the municipal wastes, lead to various types of hazards. The main hazards from the wrong management practices are given in Figure 2.1 (Patil and Shekdar, 2001).

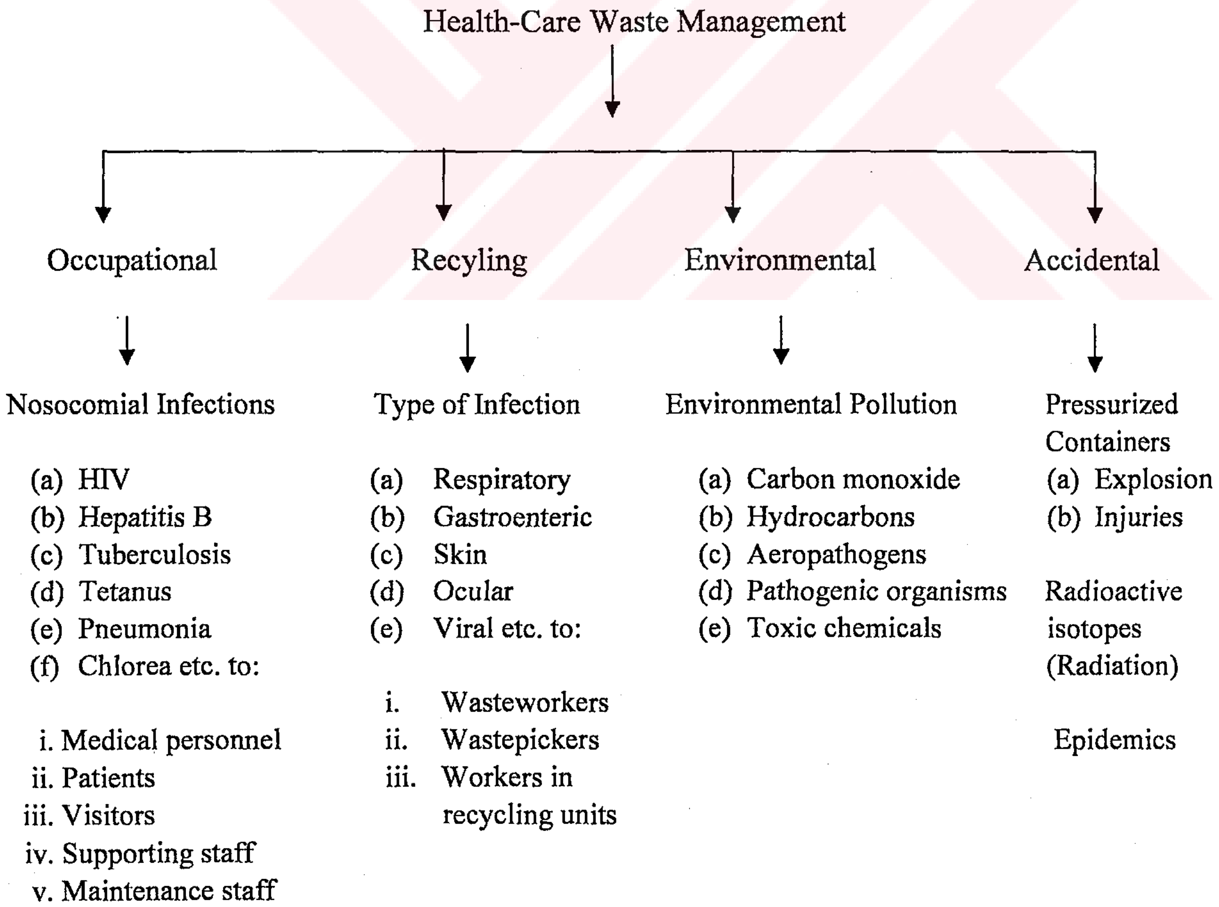

Figure 2.1. Hazards associated with the health-care waste management (Patil and Shekdar, 2001).

2.7. Management of the Health-Care Wastes

There is an increasing concern with hazards of hospital wastes as the wastes generated in the course of health-care activities carries a higher potential for infection and injury than any other type of wastes. The handling, storage, transportation, treatment, and disposal of wastes, which have enormous potential to cause sometimes irreversible health damages, call for effective management method and are a cost of doing business for the health-care institutions. The favored conclusion is a proper waste management at generator level to guarantee the reduction of the generated hazardous wastes. Nevertheless, most of the countries prefer today the "end-of-pipe" solutions (Kühling, 2002).

The important factor for improving the health-care waste management at the national, regional and local levels is to formulate and plan objectives for their achievement. Planning requires the definition of a strategy that will facilitate careful implementation of the necessary measures and appropriate allocation of resources according to the identified priorities. This is important for motivating the authorities, workers and the public and for defining further actions that may be needed (WHO, 1999). The basic elements of programs for the health-care waste management are given in the Table 2.10 (Christen, 1996).

Table 2.10. Basic elements for the management of medical wastes (Christen, 1996)

Comprehensive System	Awareness and Training	Selection of Options
(a) Assignment of responsibilities for waste management (b) Allocation of sufficient resources (c) Waste minimization, including purchasing policies and stock management practices (d) Segregation of waste into sharps, non-sharps infectious waste and non-infectious waste (e) Implementation of safe handling, storage, transportation, treatment and disposal options	(a) Awareness raising of all staff about risks related to sharps and other infectious wastes (b) Training of health-care personnel regarding segregation practices (c) Training of waste workers regarding safe handling, storage and operation and maintenance of treatment technologies (d) Display of written instructions for personnel	(a) Identification of available centralized waste management and disposal resources (b) Choice of sustainable management and disposal options, according to: i. Affordability ii. Environment-friendliness iii. Efficiency iv. Worker's safety v. Prevention of the re-use of disposable medical equipment (e.g. syringes) vi. Social acceptability

The United Nations Conference on the Environment and Development (UNCED), in 1992, had adopted the Agenda 21, which recommends a set of measures for waste management. The set of recommendations includes:

(a) prevention and minimization of production of wastes,
(b) reuse or recycling of wastes to the extent possible,
(c) treatment of wastes by safe and environmentally-sound methods, and
(d) disposal of final residues by landfill in carefully designed sites (Nessa, 2001).

2.7.1. Waste Minimization

Waste minimization is an integral part of the facility's overall waste management plan and should be considered a priority in a waste management program. The most effective alternative to face the problem of wastes in health care centers is to minimize its generation through reuse, recycling, and reduction of the quantity of materials used.

Waste minimization can be achieved through a variety of techniques, some as simple as product substitution, and some as complicated as a total process change requiring new training and equipment. The activities which are the heart of waste minimization are:

(a) prevent waste generation,
(b) reduce waste generation,
(c) reuse wastes that has been generated, and
(d) recycle wastes (Howart, 2002).

Each of the waste streams found in hospitals is governed by a specialized set of laws and regulations to ensure worker and public safety, as well as environmental protection. Some of these wastes may be found in different physical forms such as the liquid and solid states of medical wastes. A good strategy is to target the largest components of the waste stream and apply the easy waste reduction steps first. Below is a chart showing the general solid waste composition in hospitals (Figure 2.2). Contrary to popular belief, non-hazardous medical wastes makes up nearly three-quarter of the wastes generated in a hospital and should not be overlooked (Hae, 1998).

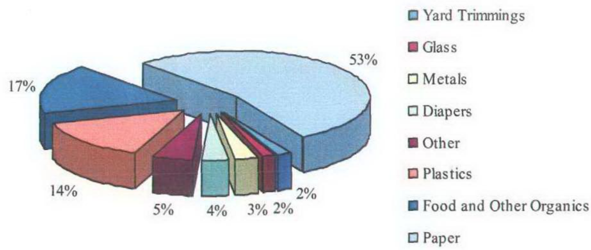

Figure 2.2. Percent solid waste composition in hospitals (http://www.ciwmb.ca.gov/BIZWASTE/factsheets/hospital.htm).

As it can be seen from the figure presented, more than half of the solid wastes at the health-care facilities is paper and cardboard. The other possibilities for recycling are packing materials, aluminum cans, crushed, tin (steel) cans, glass, newspapers, plastics, toner cartridges, fluorescent light bulbs, wood, styrofoam, computers, copy and fax machines, clothing, and scrap metals (copper, aluminum, brass).

Hospitals also generate a variety of wastes that require special treatment and/or waste management. These wastes include mercury, photographic wastes, batteries, radiology wastes, xylene, medical supplies and equipment, chemotherapy wastes, cafeteria grease, construction and demolition wastes, and other toxics and corrosives (WHO, 1999).

2.7.1.1. Components of a Successful Waste Minimization Program. The efficient waste minimization programs can be accomplished by firstly identifying the important constituents of the minimization strategies. The key components of successful waste minimization programs are summarized in the following list:

(a) effective infection control procedures,
(b) pre-cycling of packaging,
(c) source separation and proper management of solid, medical and recyclable wastes,
(d) effective guidelines for clinical staff,
(e) effective "on-going" quality management, communication and training, and
(f) management commitment and leadership (EPA, 1990).

2.7.1.2. Benefits of the Waste Minimization. Waste minimization, also known as source reduction and environmentally sound recycling, reuse, and reclamation technologies have helped many hospitals reduce:

(a) the quantity and toxicity of hazardous and infectious waste generation,
(b) raw material and product losses,
(c) waste management and raw material purchase costs,
(d) waste management record keeping and paperwork burden,
(e) workplace accidents and worker exposure,
(f) compliance violations, and
(g) environmental liability.

At the same time, waste minimization can improve management efficiency, profits, employee participation, and environmental performance (Howart, 2002)

2.7.1.3. Main Stages for the Waste Minimization.

(A) Source Reduction

The goal of source reduction is to eliminate the use of materials generating wastes in the first place. This is the fastest way to achieve cost savings and meet minimization goals. It can be accomplished by a number of methodologies: change in procurement practices to reduce wastes, substitution of a non-hazardous or less hazardous material, process change, improving inventory control, staff training to reduce wastes, or maintenance of equipment and materials (www.vh.org/Providers/CME/CLIA/LabSafety/wastemanagement.html).

(B) Segregation

An essential component of pollution prevention is the proper segregation of waste streams. Segregation of hazardous from nonhazardous wastes into different categories helps to reduce the volume and quantities of regulated wastes. Only when different types of wastes are properly separated can each be handled and treated in an appropriate manner, allowing for re-use, recycling, disinfecting, and proper disposal. Segregation is therefore a prerequisite for any sustainable waste management program (WHO, 1999).

Segregation also makes it easier to obtain baseline data, identify options, determine waste management costs, and assess the effectiveness of waste minimization strategies.

All health-service employees have a role to play in this process and should therefore be trained in waste minimization and the management of hazardous materials. This is particularly important for the staff of departments that generate large quantities of hazardous wastes. Suppliers of chemicals and pharmaceuticals can also become responsible partners in waste minimization programs. The regulated health-care wastes that can be minimized by segregation are summarized as (EPA 1993):

(a) used and unused discarded sharps (needles, syringes with needles, scalpels, pins, broken glass, pipettes, capillary tubes, glass slides, cover slips),
(b) items so grossly contaminated with blood and tissue that they would produce dripping upon compression (only saturated sponges, dressings, drapes),
(c) items substantially stained with dried blood,
(d) bulk blood and blood products; blood and body fluids,
(e) bags and tubing used to transfuse blood and blood products,
(f) microbiological wastes (cultures and stocks of infectious agents, discarded live or attenuated vaccines, culture dishes),
(g) tissues, organs, body parts removed during surgery and autopsy,
(h) contaminated carcasses, body parts, excrement, and bedding of animals inoculated with infectious agents, and
(i) waste contaminated with excretion, exudates or secretions from humans who are required to be isolated in the hospital (to protect others from highly communicable diseases).

(C) Recovery and Reuse or Recycling

Not all hazardous wastes will be able to be eliminated at the source. Certain processes will continue to require the use of materials, which will produce hazardous wastes. The second approach must therefore be the recovery and reuse or recycling of wastes. There are some opportunities with hospital wastes (e.g. xylene, ethanol, oil and batteries) for the wastes to be recovered and reprocessed (e.g. distillation, re-use, recycling). Many common single-use disposable products have also safe, reusable alternatives including sharps containers, gowns, linens, bedpans, urinals, dishware, etc. (http://www.iicph.org/docs/six_principles.htm).

Recycling is usually not practiced by health-care facilities, apart, perhaps, from the recovery of silver from fixing-baths used in processing X-ray films. However, recycling of materials such as metals, paper, glass, and plastics which are described in the preceding paragraphs can result in savings for the health-care facility-either through reduced disposal costs or through payments made by the recycling company.

In addition to recycling and reuse programs, hospitals need to focus on creating less toxic wastes in the first place. Not only does this help reduce the amount of pollution generated to create these products, but buying recycled also helps to stimulate the market for the hospital's recycled materials. Only 15 per cent of the hospital waste stream is classified as 'regulated' or 'potentially infectious', and must be handled as such.

(D) Composting

Another important strategy to minimize wastes such as food discards, kitchen wastes, cardboard, and yard wastes is composting. Some hospitals around the world have also successfully composted the placenta waste. Sufficient land space for on-site composting far enough from patient care and public access area would be needed. Food scraps can provide most of the nitrogen while bulking agents commonly found in hospitals such as cardboard and wooden chips could provide carbon (www.epa.gov/ttn/uatw/129/hmiwi/rihmiwi.html).

2.7.2. Waste Segregation and Packaging

The key to minimization and effective management of the health-care wastes is the identification of the wastes and segregation (separation) as it is mentioned above. The most appropriate way of identifying the categories of the health-care wastes is by sorting the wastes into colour-coded plastic bags or containers. In addition to the colour coding of the waste containers, the practices described in the following paragraphs are recommended.

Appropriate containers or bag holders should be placed in all locations where particular categories of wastes may be generated. Instructions on waste separation and identification should be posted at each waste collection point to remind the procedures to the staff. Containers should be removed when they are three-quarters full.

General health-care wastes should join the stream of domestic refuse for disposal. Since costs for safe treatment and disposal of hazardous health-care wastes are typically more than 10 times higher than those for general wastes, all general wastes should be handled in the same manner as domestic refuse and collected in black bags.

All non-sharp medical wastes must be segregated at the point of generation and placed in single or double-thickness biohazard bag. The bag must be strong enough to prevent tearing or bursting, be red in color and bear the word "biohazard" with the international biohazard symbol (Figure 2.3).

Figure 2.3. International infectious substance symbol (Ministry of Environment and Forestry of Turkey, 1993).

Presently, the health-care wastes at the institutions of the European Side are collected separately in the puncture and tear resistant red bags of 150 micron thickness, having the international “medical waste symbol” and the statement “Caution-Medical Wastes” while the recyclable and the domestic wastes are collected in black and blue coloured bags respectively (Figure 2.4).

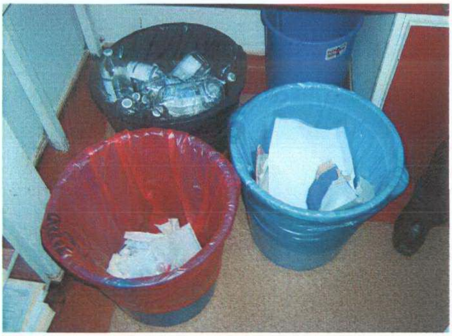

Figure 2.4. Waste collection in required different coloured waste bags.

Color coding applications of wastes according to their types is given in Table 2.11 as an example (EPA, 1993).

Table 2.11. Color coding applications of the wastes according to the types (EPA, 1993)

Color of Container / Bag	Type of Waste
Black	Non-infectious dry wastes
Green	Non-infectious wet wastes (kitchen, dietary etc.)
Red	Infectious and pathological wastes
Red with black band	Chemical wastes including heavy metal wastes
Orange	Radioactive wastes
Yellow	Sharps and pressurized containers

Sharps wastes must be collected at the point of generation and they are supposed to be disinfected in a solution and deformed/crushed before placing them in a metal box (Figure 2.5). When this box becomes full, by closing its lid tightly, it is going to be put into the red bag of infected wastes to be discarded/incinerated together. No health-care wastes other than sharps should be deposited in sharps containers, as these containers are more expensive than the bags used for other infectious wastes.

Figure 2.5. The yellow sharp-box for the collection of the sharps.

Large quantities of chemical wastes should be packed in chemical resistant containers and sent to specialized treatment facilities (if available). The identity of the chemicals should be clearly marked on the containers; hazardous chemical wastes of different types should never be mixed.

Animal carcasses and animal parts require incineration and must be packaged separately from other wastes. Animal parts must also be collected in a double or single red biohazard bag bearing the word "Biohazard" and the international biohazard symbol and be labeled "incinerate only". The preservative agents such as formaldehyde, phenol or glycol solutions must be poured off, collected and disposed of as hazardous wastes. Wastes with a high content of heavy metals (e.g. cadmium or mercury) should be collected separately.

2.7.3. Labeling

All waste bags or containers should be labeled with basic information about their content and the producer. For health-care wastes, the additional information should be marked on the label as the waste category, date of collection, department of the hospital where produced (e.g. ward), and waste destination. In case of problems involving questions of liability, full and correct labeling allows the origin of the wastes to be traced. Labeling also warns operative staff and the general public of the hazardous nature of the wastes (WHO, 1999).

2.7.4. On-Site Collection of Health-Care Wastes

Wastes should not be allowed to accumulate at the point of production. A routine program for their collection should be established as part of the health-care waste management plan. The ancillary workers in charge of waste collection should follow certain recommendations:

(a) Wastes should be collected daily (or as frequently as required) and transported to the designated temporary waste storage site.

(b) No bags should be removed unless they are labeled with their point of production (hospital and ward or department) and contents.

(c) The bags or containers should be replaced immediately with new ones of the same type (WHO, 1999).

Domestic and medical wastes should not be loaded and carried on the same collection. There should be separate vehicles for the collection of domestic and medical wastes. Waste removal vehicles shall be cleaned and disinfected at least once every week. If a waste bag bursts in the vehicle, wastes shall be unloaded and the vehicle should be cleaned.

2.7.5. Storage of the Health-Care Wastes

Health-care facilities are instructed to dispose medical wastes regularly to avoid accumulation. All health-care wastes should be collected and stored in a temporary waste storage area until transported to a designated off-site treatment facility.

In İstanbul, hospitals having minimum 20 bed capacities are compelled to build interim storage structures or use special containers for the temporary storage of the health-care wastes. Waste may be retained in these stores or containers for not more than 48 hours before removal to final disposal sites. The institutions having no bed or less than 20 beds are not supposed to construct a temporary storage room, but should make an agreement with the nearest institution to use their temporary storage room.

A temporary storage location for the health-care wastes should be designated on the premises of the health-care establishment or research facility. Temporary waste storage rooms should be constructed in the form of two chamber enclosed structures; one for the deposition of domestic wastes and the other for the health-care wastes. Floors shall be terrazzo on concrete base and walls ceramic tiled ceilings shall be fine cement plaster on concrete, oil paint finished. Heat buildup within the interim waste storage should be eliminated and bacteria/retaining air filters should be installed. Store dimensions must be adequate for deposition of minimum two days' production of waste. Chamber doors shall be outward swinging wing door or sliding door type. Doors shall be maintained constantly clean and well-painted, closed and locked, with "International Waste Logo" on the panels.

Chambers for the storage of domestic wastes should contain a grid-enclosed drain pit connected to the sewer system, and a pressure water valve. The chambers shall be washed and disinfected with special chemicals at least once every two weeks (Figure 2.6).

Figure 2.6. Temporary storage room for the domestic wastes.

Chambers for the health-care wastes shall be provided with a drainage system connected not to the sewer system but to a special leak/tight tank. Cleaning and disinfection of liquid leakages resultant from bursting of medical waste bags should be done by dry methods. Liquid collecting in the drain tank shall be thickened by mixing with sawdust and stored together with regular medical waste. Chambers shall be cleaned at least once a week or immediately after an accident (Figure 2.7).

Figure 2.7. Temporary storage room for the health-care wastes.

Subject to procurement of municipal, containers may be also used for temporary storage of waste. Waste containers should be located to prevent undesirable effects of climatic conditions. Containers shall be cleaned at least once a week, or immediately after an accident (Ministry of Environment and Forestry of Turkey, 1993).

2.7.6. Transportation of the Health-Care Wastes

2.7.6.1. On-Site Transportation of the Health-Care Wastes. The health-care waste generator is responsible for the safe packaging and adequate labeling of wastes to be transported off-site and for authorization of its destination. Waste bags may be placed directly into the transportation vehicle, but it is safer to place them in further containers (e.g. cardboard boxes or wheeled, rigid, lidded plastic or galvanized bins). This has the advantage of reducing the handling of filled waste bags but results in higher disposal costs. These secondary containers should be placed close to the waste source (Nessa, 2001).

Vehicles or containers used for the transportation of health-care wastes should not be used for the transportation of any other material. They should be kept locked at all times, except when loading and unloading (Öztürk and İskenderoğlu, 2002).

2.7.6.2. Off-site Transportation of the Health-Care Wastes. Before the transportation of wastes, dispatch documents should be completed, and all arrangements should be made between consignor, carrier, and consignee.

In Istanbul, Metropolitan municipalities, district municipalities or their assigns are collectively and successively responsible for the removal of medical wastes from interim stores or containers, transportation to disposal sites and disposal by incineration or final storage, as well as for training of the personal involved and documentation of these operations. Where necessary, the Ministry will provide cooperation in this respect to the municipalities. Medical waste materials shall be brought to final disposal sites in a safe manner without strewing around and straining of liquids and no transfer stations shall be used in transportation (Ministry of Environment and Forestry of Turkey, 1993).

According to the Turkish Medical Waste Regulation, vehicles used for the transportation of medical waste materials:

(a) should not contain compaction mechanisms,
(b) should have totally enclosed loading tanks being of robust construction,
(c) interior surfaces should be smooth and easily cleanable and not have sharp corners,
(d) should bear the "International Clinical Waste" logo in front and in the rear,
(e) exposed surfaces shall be painted orange (Figure 2.8),
(f) "Dikkat - Tıbbi Atıklar" (Caution -Medical Waste) shall be painted on the two sides in 20 cm tall lettering (Ministry of Environment and Forestry of Turkey, 1993).

Figure 2.8. The appropriate medical waste collecting vehicle.

2.8. Routing of the Health-Care Wastes

The problem of optimally routing and scheduling collection of the health-care waste from a disperse group of hospitals was recognized as a periodic vehicle routing problem. The collection and transportation cost constitutes 80 to 95 per cent of the total budget of waste management, hence it forms the key component in determining the economics of the whole waste management. Besides other factors, collection and transportation time, routing, the design and carrying capacity of vehicles, types of bins have significant effect on the efficient waste management system (Shih and Chang, 2001).

2.9. Treatment and Disposal

When recovery for reuse or recycling is not feasible, the next step is the treatment that any process designed to change the physical, chemical or biological character or composition of the hazardous wastes. Regulated medical wastes are treated or decontaminated to reduce the microbial load in the wastes and to render the by-products safe for further handling and disposal. Of all the categories comprising regulated medical wastes, microbiological wastes (e.g., untreated cultures, stocks, amplified microbial populations) pose the greatest potential for infectious disease transmission, and sharps pose the greatest risk for injuries. Untreated stocks and cultures of microorganisms are subsets of the clinical laboratory or microbiological waste stream (Ferraz and Affonso, 2003).

Historically, treatment methods involved autoclaving (steam-sterilization) and incineration. Alternative treatment methods developed in recent years include, but are not limited to chemical disinfection, grinding/shredding/disinfection methods, energy-based technologies (e.g., microwave or radiowave), and disinfection/encapsulation methods. Different kinds of disposal/treatment methods of medical wastes are shown in Table 2.12 (Rutala and Mayhall, 1992).

Table 2.12. A different kinds of disposal/treatment methods of medical wastes (Rutala and Mayhall, 1992)

Source/Type of Medical Waste	CDC[1] Disposal/Treatment Methods[2]	EPA Disposal/Treatment Methods[2]
Microbiological (stocks and cultures of infectious agent, etc.)	S, I	S, I, TI, C
Blood and blood products	S, I, Sew	S, I, Sew, C
Pathological (e.g. tissue, organs)	I	I, SW, CB
Sharps	S, I	S, I
Communicable disease isolation	-	S, I
Contaminated animal carcasses, body parts and bedding	S, I (carcasses)	I, SW (not bedding)
Contaminated laboratory wastes	-	If considered IW, use S or I
Surgery and autopsy wastes	-	If considered IW, use S or I
Dialysis unit	-	If considered IW, use S or I
Contaminated equipment	-	If considered IW, use S or I

[1]CDC = Centers for Disease Control (in USA)
[2]I = incineration; S = steam sterilization; TI = thermal inactivation; C = chemical disinfection for liquids only; Sew = sanitary sewer (EPA requires secondary treatment); SW = steam sterilization with incineration or grinding; CB = cremation or bruial by mortician; IW = infectious wastes.

The final choice of the treatment system should be made carefully, on the basis of various factors, many of which depend on local conditions:

(a) disinfections efficiency,

(b) health and environmental considerations,

(c) volume and mass reduction,

(d) occupational health and safety considerations,

(e) quantity of wastes for treatment and disposal/capacity of the system,

(f) types of wastes for treatment and disposal,

(g) infrastructure requirements,

(h) locally available treatment options and technologies,

(i) options available for final disposal,

(j) training requirements for operation of the method,

(k) operation and maintenance considerations,

(l) available space,

(m) location and surroundings of the treatment site and disposal facility,

(n) investment and operating costs,

(o) public acceptability, and

(p) regulatory requirements (WHO, 1999).

In the following sections, best known technologies for the treatment of the health-care wastes including the incineration, autoclaving, microwaving, chemical disinfection, wet and dry thermal treatment, plasma and landfill disposal methods are given.

2.9.1. Incineration

Incinerations are considerably more costly technologies compared with alternative methods of waste treatment. The main advantages include significant volume reduction of the wastes, while requiring little processing of wastes before treatment whereas the disadvantages include high cost and potential pollution risks associated with incineration processes. These systems contribute to the considerable loading of the environment with gaseous, solid and liquid wastes and additionally reduce the potential for the recovery of secondary raw materials.

Incineration equipment should be carefully chosen on the basis of the available resources and the local situation. Three basic kinds of incineration technology are of interest for treating health-care wastes:

(a) rotary kilns operating at temperatures of 1200°C to 1600°C, capable of decomposition of genotoxic substances and heat-resistant chemicals,

(b) double-chamber pyrolytic incinerators, which may be especially designed to burn infectious health-care wastes at temperatures of 800°C to 900°C,

(c) single-chamber furnaces with static grate, burning temperature of 300°C to 400°C which should be used only if pyrolytic incinerators are not affordable, and

(d) simple field incinerators with burning temperature of <300 °C (Diaz, 2002).

Waste types that cannot to be incinerated are pressurized gas containers, large amounts of reactive chemical wastes, radioactive wastes, silver salts and photographic or radiographic wastes, halogenated plastics such as polyvinyl chloride (PVC), wastes with high mercury or cadmium content, such as broken thermometers, used batteries and lead-lined wooden panels, and ampoules of heavy metals (KUO, 1999).

In Turkey, incineration is the preferred method for the disposal of health-care wastes; however huge portion of the health-care wastes is disposed with domestic wastes. There are seven incineration facilities in Turkey, which are located in İstanbul, Ankara, Antalya, Sivas, Muğla and Kocaeli. In İstanbul, health-care wastes collected systematically by İSTAÇ from health establishments are brought to the Storage Area in Kemerburgaz-Odayeri and discarded here by burning in the Health-Care Waste Incineration Plant, established in 1995, in high temperatures (Öztürk and İskenderoğlu, 2002).

Curiously, the health-care wastes taken to the Kemerburgaz-Odayeri Incineration Plant are firstly weighted and after loading mechanically, incinerated in the primary combustion chamber at around 800-900 °C. During the incineration of the organic parts, pathogenic organisms are destroyed and the 95 per cent reduction as volume and 80 per cent reduction as mass can be accomplished. The minimum detention time of the wastes in this unit is one hour.

After the primary chamber, for the incineration of the generated gases, wastes are incinerated in the secondary combustion chamber operating at around 1100-1200 °C and this stage is finished in 1.5-2 seconds. By the secondary chamber, hazardous organic materials such as dioxin and furans are destroyed on a large scale. The high concentration of the carbon monoxide is the indicator of the incomplete combustion and in this situation; the amounts of hydrocarbons, dioxin and furans, PCBs that are incinerated incompletely will be very high.

After these gases and dusts are treated by the flue-gas scrubbing system in order to reduce their concentration below the standards given in the Regulation, they are emitted in to the atmosphere through the dust-filtration system. Ashes produced by incinerators from combustion of the medical wastes are carried by special medical waste collection trucks to the final disposal sites described in the Regulation, dumped at the sanitary landfill specially designed for the hazardous wastes and then compacted and covered by earth. The ash and wastewater produced by the process can contain considerable quantities of heavy metals, such as lead, cadmium, and mercury, and may contain even more toxic elements such as organohalogens (Davis, 1997).

On the other hand there are several alternative technologies for disinfecting health-care wastes such as autoclaving, micro waving, chemical disinfecting, wet and dry thermal plasma, pyrolysis and fusion, etc. which do not produce those gases (WHO, 1999).

2.9.2. Autoclaving (Steam Sterilization)

Autoclaving, or steam sterilization, is a process to sterilize medical wastes prior to disposal in a landfill. This is a primary treatment and is usually followed by secondary treatment including landfilling, shredding and incineration. Typically, for autoclaving, bags of health-care wastes are placed in a chamber (which is sometimes pressurized). Steam, dry heat or radiation is introduced into a tightly sealed chamber for roughly 30-90 minutes at the temperature of minimum 121 °C. Although the efficiency of this method reaches to 80 per cent reduction by volume, the weight remains unchanged (WHO, 1999).

Autoclaves actually provide some advantages over incineration, which may increase their attractiveness as a disposal option. Operation and testing of incinerators is more complex and difficult than that for autoclaves. Also the effluent gases generated through the incinerators contain wider range of constituents, while in the autoclaves; the waste at the end is inert and can be disposed at the municipal landfill. Additionally autoclaves are less costly to purchase and require less space. Both autoclaving and incineration require exact and precise operation and maintenance. The problems come after autoclaving is complete and transportation is required. The autoclaving method is widely used for recyclable wastes and is not recommended however for the treatment of some types of wastes including the chemotherapy, pharmaceutical, laboratory and pathological wastes (Waste Prevention Association, 2001).

2.9.3. Microwaving

Microwave is the destruction of the microorganisms through the activity of waves with the frequency of 2 450 MHz and wavelength of 12.24. Wastes are disinfected with microwave heat at 94°C for a minimum exposure time of 25 minutes. Before the process, the wastes are shredded and granulated consequently to obtain the 80 per cent volume reduction. As the system is a totally closed system, it does not cause any emissions. Microwave technology has been approved and is commercially operable in Europe and the United States (Waste Prevention Association, 2001).

2.9.4. Chemical Disinfection

Chemical agents have been used as disinfectants for medical products, although the application to large volumes of infectious wastes generated by hospitals and laboratories is more recent. This type of technology, which has been available since the mid-1980s, is referred to as "mechanical/chemical" because of mechanical maceration and chemical disinfection. The residue is discharged to the sewer system (Prüss *et al.*, 1999).

A variety of chemicals has been proposed for the disinfection. The most commonly used disinfectant agents are aldehydes, chlorine compounds, ammonium salts and phenol compounds. The combination of the disinfection process with the shredding and a heat process leads to the reduction of waste volume by 60-90 per cent (Waste Prevention Association, 2001).

Chemical disinfection processes, according to EPA, are most appropriate for liquid wastes, although they can be used to treat solid wastes. A number of factors should be considered regarding the effective use of chemical disinfection, including: the types and biology of microorganisms in the wastes; degree of contamination; type of disinfectant used (usually sodium hypochlorite, commonly known as chlorine bleach) and its concentration and quantity; the contact time; mixing requirements; etc. (EPA, 1993).

2.9.5. Wet Thermal Treatment

Wet thermal treatment systems are exposes shredded infectious wastes to steam under high-pressure and high-temperature. It inactivates most types of microorganisms if temperature and contact time are sufficient; for sporulated bacteria, a minimum temperature of 121°C is needed. Investment and operating costs are low; it is an environmentally friendly process. The wet thermal process requires that wastes be shredded before treatment; for sharps, milling or crushing is recommended to increase disinfections efficiency. The process is inappropriate for the treatment of tissues and animal carcasses, and will not efficiently treat chemical or pharmaceutical wastes.

Autoclaving is an efficient wet thermal disinfections process. Typically, autoclaves are used in hospitals for the sterilization of reusable medical equipment. They allow for the treatment of only limited quantities of wastes and are therefore commonly used only for highly infectious wastes, such as microbial cultures or sharps. It is recommended that all general hospitals, even those with limited resources, be equipped with autoclaves (WHO, 1999).

2.9.6. Dry Thermal Treatment

Screw-feed technology is the basis of a non-burn, dry thermal disinfections process in which wastes are shredded and heated in a rotating auger at 110–140°C for about 20 minutes, after which the residues are compacted. The wastes are reduced by 80 per cent in volume and by 20–35 per cent in weight. Exhaust air and water emissions should be treated before discharge. This process is suitable for treating infectious wastes and sharps, but it should not be used to process pathological, cytotoxic, or radioactive wastes (WHO, 1999).

2.9.7. Pyrolysis and Fusion

The plasma pyrolysis medical waste disposal system combines plasma with pyrolysis. The extreme temperatures convert organic material to mid-grade fuel gas which is primarily hydrogen and carbon monoxide. Acidic material is removed by a scrubbing process and inorganic materials can be recovered or vitrified with glass. The process can handle all types of wastes and results in reductions of up to 90 per cent in volume and 80 per cent in weight. The market for plasma pyrolysis technology includes very large hospitals and regional treatment facilities (Waste Prevention Association, 2001).

2.9.8. Thermal Plasma

Thermal inactivation uses heat to reduce infectious agents in wastes. It is used to treat cultures and stocks, pathological and fluid animal wastes. It is generally used for liquid medical wastes. Successful treatment relies on the wastes being exposed to a minimum temperature for a minimum period to ensure destruction of all pathogens. The treated and cooled liquid wastes are normally discharged to the sanitary sewer (Rutala, 1992).

2.9.9. Irradiation

Irradiation processes such as ultraviolet and ionizing radiation by gamma rays can be used for sterilization. Radiation is used for sterilizing certain products but seldom used to sterilize infectious wastes. This is because of high costs, need for extensive protective equipment, and requirement of highly trained operating personnel and problems with the disposal of the radioactive source. Ultraviolet light cannot penetrate material to any depth; therefore its use is limited to sterilization of surfaces. Gamma rays from the radio isotope cobalt–60 do penetrate to a greater depth; hence this technology is applicable to infectious waste sterilization. However, it is now rarely used for waste treatment (Waste Prevention Association, 2001).

2.9.10. Landfill Disposal

If a municipality or medical authority cannot manage to treat wastes before disposal, the use of a landfill has to be regarded as an acceptable disposal route.

Identifiable body tissue, cytotoxic wastes, pharmaceutical, laboratory or domestic chemicals, radioactive wastes, infectious wastes (only as exemption) are generally considered as not suitable for disposal at a landfill site. Soiled animal bedding, incontinence pads and other faeces/urine contaminated materials, health-care wastes which has been made safe by autoclaving in an autoclave, bulky, or large, items which are impractical to dispose of via incineration may be considered for landfilling with the prior approval of the local authority (Karaca, 2002).

In İstanbul, in instances where disposal by incineration prove impossible, medical wastes are neatly deposited for storage at a specially allocated part of dangerous waste deposition areas, a specially allocated part of domestic waste deposition areas constructed according to the requirements of this Regulation or a special disposal site prepared for the medical wastes only.

3. METHODOLOGY

3.1. Site of the Research

This study was conducted on the health-care institutions in the European Side of İstanbul which is the largest metropolitan city of Turkey. It is also one of the most crowded cities in the world. This research covers 132 hospitals in the European Side of İstanbul including the state, private, university, research, military hospitals and social insurance institutions hospitals. Within the scope of the research, 241 polyclinics in the European Side were also taken into consideration.

3.2. Procedure

In order to define the activities in a systematic way, the study conducted in several stages that are interlinked to each other in designing an integrated health-care waste management plan. In the following paragraphs, the activities that took place within these stages were described. The stages can be summarized as follows:

(a) review of the existing institutional and legislative framework,
(b) overview of the sources and current practices by field research,
(c) development of the questionnaires,
(d) analysis of the current situation,
(e) database development,
(f) statistical analysis of the results,
(g) laboratory analysis,
(h) investigation on waste minimization,
(i) development of a waste collection network,
(j) alternative treatment and disposal methods, and
(k) designing a waste management structure.

3.3. Review of the Existing Institutional and Legislative Framework

In this stage, the Turkish Medical Waste Control Regulation was analyzed and the main problems faced in the implementation of the Regulation at the health-care institutions and the deficiencies of the regulation in comparison with the EU legislation were evaluated. Necessary changes that should be made and further suggestions about the institutional structure in the health-care waste management are stated.

3.3.1. Evaluation of the Regulation

Health-care wastes have been a problem for Turkey especially in the metropolitan cities which cause a significant health-care waste generation. In the early 1990s, the health-care wastes used to be collected with the domestic wastes together and dumped into the open dumps. Although this situation caused significant drawbacks and generated many risks for the public health and environment, this problem has not been solved for years even after the publication of the Turkish Medical Waste Control Regulation.

The Turkish Medical Waste Control Regulation was adopted in May 20th, 1993. The Regulation comprised from the eight chapters.

In the Chapter One, the summary of the content and the main purpose of the Regulation, definitions of the terminology used in handling the health-care wastes and the facilities that have the potential to generate the health-care wastes are described. The second chapter includes the list of the duties of the responsible parties for the management of the health-care wastes and financial obligations of wastes.

In the Chapter Three, classification of the health-care wastes as domestic and medical wastes and requirements for the collection, transport and treatment schemes of these wastes in the units are identified. Chapter Four explains the design specifications of the temporary storage rooms of the health-care wastes, obligations for the small (having less than 20 beds or no bed at all) and large (having minimum 20 bed capacities) health-care institutions, licensing and operational and control of the temporary storage room designated for the health-care institutions.

Transportation of the collected health-care wastes to final disposal areas and the responsibilities of the parties in this activity including the municipalities and private companies are described in the Chapter Five. The specifications for the health-care waste transport vehicles are stated.

In Chapter Six, facilities for the incineration of the health-care wastes, maximum allowable limits for the gaseous emissions generated from the incineration furnaces, approval and cancellation of licensing and control of the incinerator operation are defined. This chapter covered the selection criteria including the drainage system, top cover, disposal site, etc. and the operation and control of the final disposal site designed for the health-care wastes.

In the last chapter, the subject on the monitoring and inspection, the penalties and administrator of the Regulation were described.

The Regulation also includes eight Annexes as follows;

(a) in Annex 1, by-products of the non-hazardous chemical compounds are given,
(b) in Annex 2, the criteria for the identification of the hazardous wastes are listed,
(c) in Annex 3, the recoverable hazardous chemical wastes are listed,
(d) in Annex 4, the readily reactive hazardous chemical compounds are given,
(e) in Annexes 5 and 6, the design of the sanitary landfills are explained,
(f) in Annex 7, the logo of the international label for the health-care wastes is given,
(g) finally, in Annex 8, the typical tracking forms for different activities of the management of the health-care wastes are presented.

3.3.2. The Comparison of the Turkish and European Legislations

When the Turkish Medical Waste Control Regulation was compared to other legislations adopted by the EU countries, the main differences faced are given as following (Council Directive 99/31/EC; 2000/76/EC and 91/689/EC);

(a) In Turkey, there is a single regulation published dealing with the control of the health-care wastes in an integrated approach. On the other hand, there is no single directive, decision or regulation in European Union (EU) Legislation referring to the management and disposal of the health-care wastes as a whole. There are a number of directives, decisions and regulations that describe the measures to be taken for various types of wastes (municipal, hazardous, dangerous, toxic etc.).

(b) The Turkish Medical Waste Control Regulation sets the criteria for the classification of the health-care wastes as dangerous substances. But the criteria set by the EU Legislation are more strict and updated.

(c) The emission levels in the Regulation are identical for parameters such as total dust, HCl, HF, SO_2, TOC and furans with the EU Legislation. The Turkish Regulation though was stricter on NO_x emissions while the EU Legislation had lower limits for the concentration of heavy metals at the effluent gas.

(d) Additional provisions are directions on the procedures to be followed during the delivery and reception of the waste to be incinerated. Measurement requirements, access to information and public participation, abnormal operating conditions and review clauses are topics that are covered additionally by the EU Legislation.

(e) The major difference between the Turkish Medical Waste Control Regulation and the EU Legislation on the landfilling of the health-care wastes was that according to the latter legislative act, infectious waste should not be landfilled in any case.

(f) Other provisions that the latter Legislation has and which is missing at the Turkish Regulation is the installation of a drainage system for the top cover, measures to minimize hazards arising from noise and traffic, birds, vermin and insects, formation of aerosols, fires, emissions of odours and dust etc.

(g) In comparison with the EU, Turkish Regulation does not cover the data on surface water, groundwater, topography of the landfill site, etc. except testing of the quantity and quality of the generated leachate.

3.4. Overview of the Sources and Current Practices

Within the scope of this stage, the current collection, transportation, treatment and disposal practices of the health-care wastes, the institutional requirements and responsibilities of the municipality were analyzed through by the review of the existing regulation, published data and existing studies. Consequently, the main problems resulting from the currently used management activities are identified. Furthermore, the lack of information, main problems in collecting the data concerning the quantities of the health-care wastes and insufficient awareness and participation of the institutions were stated. As a following stage, to obtain a reliable statistical data about all the subjects related to the health-care waste management in the institutions, a detailed field research was conducted.

3.5. Field Research

The study was based on an exhaustive field research that would solve the problem of lack of information and on the development of an inventory that would be used for the systematic registration of the data. In order to conduct the field research, exhaustive surveys that were based on mainly questionnaire were carried out and personnel interview and visits on the health-care waste generation sources were realized.

3.5.1. Development of the Questionnaires

Surveys based on detailed and relevant questionnaires. For the health-care institutions and the district municipalities, two different types of questionnaires were prepared. While the first one was filled by the responsible authorities of the all health-care institutions; the second one was received from the district municipalities to control the reliability of the data obtained from the first questionnaire. Finally, all the data gathered was evaluated with respect to the data supplied by the ISTAÇ which is a company of the Municipality of the

Metropolitan City of İstanbul for the collection and transportation of the health-care wastes from the institutions to the final disposal area.

3.5.1.1. The Questionnaire of the Health-Care Institutions. In this questionnaire prepared for the health-care institutions, the personnel responsible for the health-care waste of the institutions were asked many questions. In the following paragraphs all the parts of the questionnaire are described.

In the first part, health-care institutions were evaluated under the categories as state, private, university, research, social insurance institutions and as polyclinics. This part consisted of the name and the location of the hospitals, activities in the institutions including the surgeries and births, bed capacities, number of doctors, nurses, sanitation, managerial, administrative and technical personnel, and average number of visitors comprising the inpatients and outpatients.

The second part was about the waste segregation, collection, transport and disposal of the health-care wastes in the institutions. In this stage, health-care institutions were asked about the type of wastes they generated. The waste types were given as pathological, infectious, radioactive, chemical, pharmaceutical and domestic wastes, sharps, pressurized containers and recyclable materials. Each management process applied was asked for each type of wastes separately. This information revealed the consciousness and knowledge of the hospital personnel about the segregation of the wastes in the appropriate containers, begs, labeling, storage, final disposal and the relevant regulations.

In the third part, interviewed people were asked for the daily quantities of wastes generated in different units of the hospitals. The waste generating units were given as three main sources. These were firstly patient services including the medical, surgical, emergency, operating theatre units; then laboratories as the biochemistry, microbiology, pathology and nuclear medicine and finally the support services like the blood bank, pharmacy, laundry, kitchen and administration. For the waste generated from the dental polyclinics in the hospitals, a table that could reveal the amount of the mercury, iron, and lead containing dental wastes was prepared. By the addition of this value, the total health-care, domestic and recyclable waste quantities in each institution could be determined.

The following part includes the information about designation, general qualification, experience, education and job description of the responsible personnel involved in the health-care waste management. In this part, there were also some questions regarding the type of the training given and its frequency.

Finally, in the last part, the interviewed people were asked for their management policy. Any legislation, policy, and documents they followed; the waste management plans, procedures, minimization targets that they had developed were identified. Additionally waste management teams of the hospital (if any) and their management performance measurement systems were all evaluated.

3.5.1.2. The Questionnaire of the District Municipalities. In this questionnaire, district municipalities were firstly asked for the number of health-care institutions in their districts. In the first part, to determine the total amount of wastes generated in the districts; the number, bed capacities and average waste quantities of the small health-care institutions of which health-care wastes were collected were identified.

In the second part, with the capacity and characteristics, total and daily number of vehicles used for the collection and transportation of these wastes were determined as well as the collection frequency and the number of travel in a day was revealed.

The third stage was about the number, duty and education of the personnel responsible for the collection and transportation of the health-care wastes and the number of the personnel assigned for one collection vehicle. The information about the work shift and working period in a day were also taken into consideration.

The fourth part included the questions about the personnel salary, the maintenance and repair cost of the waste collection vehicles and the expenditures for fuel oil/benzine used for the vehicles. The total cost spent for the collection and transportation of the health-care wastes and the income obtained in return for the collection of these wastes were also among the questions. In determining this income, affecting factors were given as per kg, bed, beg, unite, etc.

Finally, in the last part, district municipalities were asked to describe their route plan and schedule how and where the disposal took place for the collected health-care wastes.

At the end of the both questionnaires, there were sections for the information such as name, address, etc. of the interviewed personnel.

3.5.2. Personal Interviews

During the distribution of the questionnaires, in order to have the expedient results the survey also included site observations and interviews with management staff, health or support workers (waste workers, cleaners, etc.) at different levels. The information collected provided a basis for formulating the management strategy and the personal visits allowed observing the existing applications and practices from the first hand.

Most effective way to get the reliable information for the questionnaires was absolutely personal visits as the reliability of the given information was only be ensured by making visual inspection. In this respect, the research was started by the personnel visits for the distribution of the questionnaires. But these personnel visits had some difficulties. These were the transportation and lack of time because of the fact that the number of hospitals to be visited was too many and the locations of hospitals were far from each other. Therefore, alternative methods were evaluated and the distribution of the questionnaires gave a new momentum with the application of the first mailing and finally and most efficiently by faxing methods.

It must be noted that during the entire implementation of the research, close co-operation with the Ministry of Environment and Forestry, Ministry of Health, etc. was established. With the Ministries' official letters sent to each institutions' head doctor and hospital manager, the required data could be reached more easily. Thus a more complete and accurate view of the current situation and the anticipated changes could be revealed.

3.6. Database Development

After obtaining the data by field research, an information system which was a detailed inventory (database) was developed for the registration of these collected data systematically. The informative system was developed in a widely used programming language. This system had a tabular design that was adapted exactly to the first questionnaire. The database enables to reach all the information regarding any hospital easily. The tabular design of the database is presented in Figure 3.1.

Similar to the information in the first questionnaire, the database was based on the number of the institutions; number of beds; sources, types and quantities of wastes generated; personnel involved in the management of the health-care wastes, and current health-care wastes disposal practices, including segregation, transportation, storage, etc.

By the database developed, the medical wastes were classified according to their content and their hazardous character (compatible to household wastes, infectious, pathological etc.). The classification aided to the investigation of the treatment techniques during the further stages of the research.

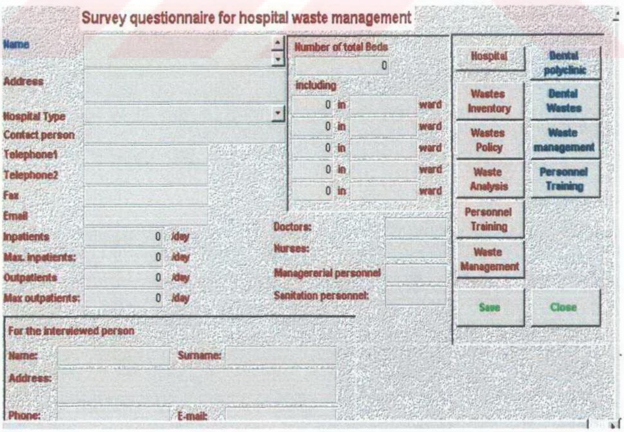

Figure 3.1. An example of a tabular design of the database.

3.7. Statistical Analysis of the Results

In this stage, the statistical analysis of the data loaded to the database was conducted. During the preparation of the data, all the data in the database were transferred into the Microsoft Excel Table-Analyze Program. After they were organized, they were then evaluated as input data in the Statistical Package for the Social Sciences (SPSS) Pack Program. The general used screen of the SPSS Program is given as Figure 3.2.

In the statistical analysis, firstly, by performing the frequency tables; mean, median, mode values, standard deviation and the minimum, maximum and total value of each variable were calculated and consequently the tables and graphs related were formed.

The statistical significance is found by using Pearson (P) Value which is the probability of the observed data. The Pearson Correlation is the coefficient that determines the direction and the degree of the relationships between the quantitative variables (Everitt, 1995).

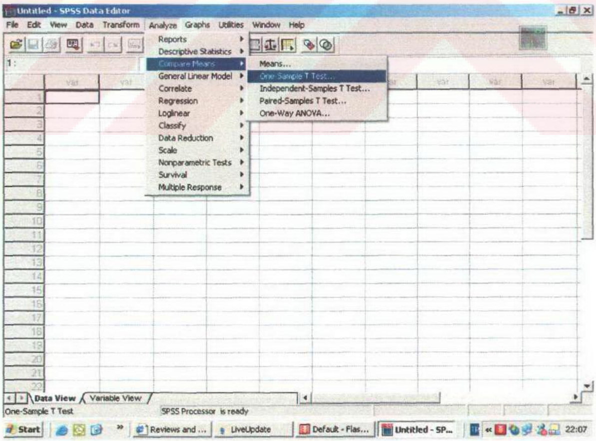

Figure 3.2. The general screen from the SPSS Program.

The interpretation of the test results are made according to the P value given below:

P>0,05	There is not a significant difference
P<0,05	Significant difference
P<0,01	Very significant difference
P<0,001	Extremely significant difference (Şenocak, 1990).

In determining the relationships, H_o (null hypothesis) and H_1 (alternative hypothesis) are used. When the $P<0.05$ (5 per cent), H_o is rejected (H_1 is accepted). This means there is a relationship between the variables. When the $P>0.05$, H_o is not rejected which means there is any relationship between the variables.

During the preparation of the data for being used in the Statistical Package for the Social Sciences (SPSS) Pack Program, all the data in the database were transferred into the Microsoft Excel Table-Analyze Program. In order to form a meaningful relationship between the parameters, firstly the selective categorical and metric variables were determined. While the metric variables were the numbers of doctors, bed capacities, quantity of wastes, number of surgery, etc., the categorical variables selected from the questionnaires were:

(a) the types of the health-care institutions as private, state, research, social security institutions and university hospitals and clinics,

(b) education level as the university, upper lycee on health and occupation, high, secondary and primary school,

(c) waste handling responsible people as the hospital personnel, private company, etc.,

(d) frequency of the training as only at new entry, once every six months, once a year, once in two years and other,

(e) the responsible personnel as head doctor, hospital manager, head nurse, nurse, manager assistant and private company employee,

(f) the type of sharp container as plastic box or bottle, sharp box, cardboard and bag,

(g) the type of temporary waste storage as waste storage room or container,

(h) the sources of the waste generation as patient services, laboratories and supportive services, and

(i) the 24 units given under the titles of these sources.

After determination of these, all the selective parameters were coded with the number as 1, 2, 3, etc. and by excluding these verbal statement, the new tables including only the numerical statement were prepared. They were then evaluated as input data in the SPSS Pack Program.

3.7.1. Frequency Tables

By performing the frequency tables; mean, median, mode values, standard deviation and the minimum, maximum and total value of each variable were calculated (Figure 3.3). The most significant waste generating unit observed in the same types of the hospitals (like the medical unit as the most observable unit for the private hospitals), the mostly observed types of the health-care wastes in the institutions (domestic wastes which has the highest frequency in all hospitals, etc.) could be the examples for the mode value. With the frequency tables, also the range and percentage distribution of each parameters were found. In Figure 3.4, an example of these tables is presented. In these tables, the frequency and percentages were evaluated with the valid values.

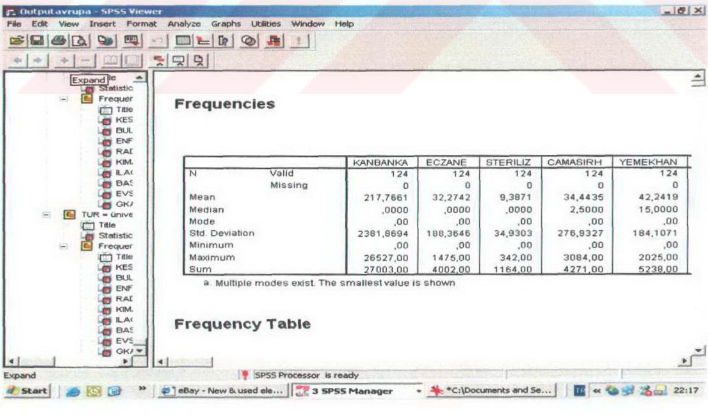

Figure 3.3. The preparation of the frequency tables by SPSS Program.

BLOOD BANK

		Frequency	Per cent	Valid Per cent	Cumulative Per cent
Valid	.00	87	70,2	70,2	70.2
	1.00	2	1.6	1,6	71.8
	2.00	5	4.0	4,0	75.8
	3.00	3	2.4	2,4	78.0
	4.00	2	1.6	1,6	79.8
	5.00	4	3.2	3,2	83.1
	7.00	2	1.6	1,6	84.7
	8.00	2	1.6	1,6	86.3
	9.00	2	1.6	1,6	87.9
	10.00	2	1.6	1,6	89.5
	15.00	2	1.6	1,6	91.1
	19.00	1	.8	,8	91.9
	20.00	3	2.4	2,4	94.4
	25,00	1	.8	,8	95.2
	35.00	3	2.4	2,4	97.6
	45.00	1	.8	,8	98.4
	75.00	1	.8	,8	99.2
	26527.00	1	.8	,8	100.0
	Total	124	100.0	100,0	

Figure 3.4. The frequency table of the blood bank with respect to the waste quantities generated.

When the Figure 3.4 is examined, it can be said that, 87 entries (70.2 per cent) of the blood banks have no waste generation. The waste generation range of 20.8 per cent of the blood bank is between one to ten kg. It is found by summing of all the percentages corresponding the waste generation from one kg to ten kg.

3.7.2. Correlation Analysis

After the frequency analysis, questionnaires were evaluated by the correlations tables created from the SPSS Program (Figure 3.5). When the Figure 3.5 is examined, it can be said that as the $P>0.05$ and this value is close to the +1, there is a strong relationship between the number of doctors and outpatients. These findings can also be explained by saying that when determining the number of doctors in institutions, the number of patients is the determining point that must be considered.

Correlations

		DOCTOR	OUTPATIENTS
NUMBER OF DOCTORS	Pearson Correlation	1.000	.798 **
	Sig. (2-tailed)	.	.000
	N	124	124
OUTPATIENTS	Pearson Correlation	.798 **	1.000
	Sig. (2-tailed)	.000	.
	N	124	124

** Correlation is significant at the 0.01 level (2-tailed).

Figure 3.5. An example for the correlation tables in the SPSS Program.

3.7.3. Parametric and Non-Parametric Analysis

In the study, non-parametric tests such as X^2 (Chi-Square) were used in the judgement of the quantitative and qualitative numerical values such as the relationships between the waste minimization practices with respect to the types of the health-care institutions, relationship between the waste management plan of the institutions with the education of the personnel, the relationships between the formulation of a management team with respect to the type of the hospitals, etc.

Parametric test (Student-t Test) was mostly used in the judgement of the quantitative measurement such as the relation between the number of doctors and the bed capacities or the relationship between the number of patients and the waste generation rate, etc. The tables formed by the X^2 analysis as named as crosstabulation tables (Figure 3.6) and by Student-t Test (Figure 3.7) were used for the comparison of the data.

Discriminant analysis was used to group the health-care institutions according to the selected variables. In this analysis, health-care institutions were grouped under the six categories as private, state, research, social insurance institution, university and military hospitals. These categories were evaluated with respect to the variables as the doctor number, bed capacities, generated waste type, waste generation source, their management practices, etc. and finally each group that the health-care institutions should be included were determined. By the discriminant analysis, the new entries to the formed groups can easily be accomplished. It means when a new hospital is opened, according to the characteristics of this hospital, the appropriate group can easily be determined; the hospital can be included to that selected group.

Minimization Target and Waste Management Crosstabulation

			Waste Management		Total
			.00	1.00	
Minimization Target	.00	Count	68	25	93
		% within Min.Target	73.1%	26.9%	100.0%
		% within Waste Mng.	86.1%	55.6%	75.0%
		% of Total	54.8%	20.2%	75.0%
	1.00	Count	11	20	31
		% within Min.Target	35.5%	64.5%	100.0%
		% within Waste Mng.	13.9%	44.4%	25.0%
		% of Total	8.9%	16.1%	25.0%
Total		Count	79	45	124
		% within Min. Target	63.7%	36.3%	100.0%
		% within Waste Mng.	100.0%	100.0%	100.0%
		% of Total	63.7%	36.3%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	14.243[b]	1	.000		
Continuity Correction[a]	12.662	1	.000		
Likelihood Ratio	13.867	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	14.128	1	.000		
N of Valid Cases	124				

a. Computed only for a 2x2 table

b. 0 cells (,0%) have expected count less than 5. The minimum expected count is 11.25.

Figure 3.6. The crosstabulation tables by the Chi-Square Analysis.

Independent Samples Test

Training Frequency	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	1.127	.291	-.812	122	.419	-.1803	.2222	-.6202	.2596
Equal variances not assumed			-1.129	30.816	.268	-.1803	.1598	-.5062	.1456

Figure 3.7. A table from the Student-t Test of the SPSS Program.

Cluster analysis was also used for the grouping of the institutions according to the selected variables. In this stage, the analyzed parameters were the 24 units of the patient services, laboratories and supportive services of the health-care institutions and the variables selected were the quantities of domestic, recyclable, infectious, pathological, pharmaceutical, chemical and radioactive wastes, sharps and pressurized containers generated. For determining the best grouping, the several numbers of clusters were applied.

In addition to the analyses, the grouping and the classification of the hospitals were also analyzed by the discriminant and cluster analyses. All the results obtained from the statistical analyses are presented in the Results and Evaluation Chapter.

3.8. Laboratory Analysis of the Health-Care Wastes

In the scope of the study, microbiological analyses were conducted to classify the health-care wastes according to their composition and to detect hazardous character and the quantity of the infectious parameters in the composition of the health-care wastes disposed from the health-care institutions. The waste composition study was a part of continuing effort to measure and evaluate the wastes generated in hospitals.

To determine the relevant experimental analysis that could be conducted to health-care wastes, the hospital infections arisen from the various pathological microorganisms (bacteria, viruses, protozoons, fungi, Staphyloccoccus aureus, Bacteria coli, Salmonella, Psedomonas aeuginosa, Enterobacter etc.) were examined. After the determination of the experimental analysis applicable for the health-care wastes, the laboratory that was suitable for the analysis was identified and procurement of the laboratory was handled.

The most observable microorganisms causing the hospital infections in the institutions are determined as bacteria, viruses, protozoon, fungi, Gram positive microorganisms such as Staphylococcus aureus, Streptococs and Salmonella and Gram negative microorganisms including the E. coli, Klebsiella, Pseudomonas Aeuginosa, Serratia, Enterobacter etc. In the recent years, Legionella species, Acinetobacter, Flavobacterium and P. aeruginosa are also determined as the microorganisms that cause nosocomial infections. The classification and the distribution of the determined pathogens in the endemic and epidemic hospital infections are given in Table 3.1 (Stamm *et al.*, 1981), Table 3.2 (Wenzel, 1991) and Table 3.3 (Haley, 1986).

Table 3.1. The pathogens causing infections in the hospitals (Stamm *et al.*, 1981)

Pathogens	Endemic	Epidemic
E.Coli	19	3
Enterococcus	10	<1
S. Aureus	10	12
Pseudomonas	9	4
Proteus	8	<1
Klebsiella	8	3
Enterobacter	4	7
Grup-A. Strep.	2	3
Serratia	2	8
Salmonella	<1	11
Hepatit B	<1	10

Table 3.2. The distribution of pathogenic microorganisms generated from the inpatients with respect to the clinic samples (Wenzel, 1991)

Type	Blood	Urine	Wound	Respiration	Liquids	Other	Total	(%)
Koag. (-) staf.	82	28	91	82	9	3	271	41,24
S. Aerous	26	1	50	26	5	7	111	16,89
E.Coli	4	86	16	4	1	-	127	19,34
Enterobacter	5	29	17	21	4	4	80	12,18
Proteus	-	16	7	3	-	4	30	4,57
Pseudomonas	-	15	8	11	1	3	38	5,78
Total	117	175	189	135	20	21	657	100
%	17,80	26,64	28,77	20,55	3,04	3.20	100	100

Table 3.3. The agents of the hospital infections (Haley, 1986)

Microorganisms	**Percentage (%)**
Aerobe Bacterium	91
Anaerobe Bacterium	2
Fungus	6
Others (Viruses, protozoon, etc.)	1
Total	100

After the examination of these findings, the analyses conducted in the scope of the study as well as the followed procedures were determined as the following:

(a) total coliform microorganism colony count method (FAO, 1992),

(b) total coliform bacteria colony count method (FAO, 1992),

(c) Escherichia coli colony count method (FAO, 1992),

(d) Enterobacter colony count method (TSI, 1996),

(e) Pseudomonas spp colony count method (FAO, 1992),

(f) Staphylococcus aureus colony count method (FAO, 1992),

(g) Bacillus cereus colony count method (TSI, 2000),

(h) Salmonella spp colony count method (FAO, 1992),

(i) Legionella colony count method (FAO, 1992), and

(j) Yeast and Moulds colony count method (FAO, 1992).

The basic equipment and materials used in the microbiological analysis were growth media containing necessary nutrients for growing microorganisms, bag-mixer for homogenization, Erlenmeyer flasks, sterile pipettes and Petri dishes, dilution bottles, Bunsen burner, which was used to perform aseptic technique to eliminate any potential contamination, incubator used for growing cultures, refrigerator for cooling and maintaining the temperature of samples and cultures between 0 °C and 4.4 °C until tested and for storage of prepared media when desired, water bath that was used to melt and keep the media melted, colony counter, pH meter and etc.

For the preparation of the growing media, various types of agar were used in the colony count methods as given in Table 3.4.

Table 3.4. The types of agar used in different colony count analyses

The Colony Count Analyze Parameters	The Type of Used Agar
The total coliform microorganism	Violet red bile glucose agar
Total coliform bacteria	Plate count agar
Escherichia coli	Plate count agar
Enterobacter	Violet red bile glucose agar
Pseudomonas spp.	mPA selective agar
Staphylococcus aureus	Trypticase soy agar, Toluidine blue-DNA agar, Tryptone yeast extract agar
Bacillus cereus	Glucose agar, nitrate agar and Voges-Proskauer agar
Salmonella spp	Xylose Iysine desoxycholate agar, Hektoen enteric agar, Bismuth sulfite agar
Legionella	Tryptose-sulfite-cycloserine agar
Yeast and Moulds	Plate count agar

The reagents used in the microbiological analysis were:

(a) peptone diluted fluid,

(b) potassium dehyrodgen phosphate,

(c) mercuric chloride solution (0.1 per cent),

(d) potassium hydroxide solution (40 per cent),

(e) tartaric acid solution (10 per cent),

(f) nitrite detection reagents,

(g) glycerin-salt solution,

(h) gram stain reagents,

(i) bromthymol blue solutions (0.04 per cent),

(j) methyl red indicator,

(k) brillent green dye sollution (1 per cent),

(l) lactose broth,

(m)selenite cystine broth,

(n) tetrathionate broth,

(o) tryptone broth (1 per cent),

(p) koser citrate broth,

(q) brain heart infusion broth,

(r) lysostaphin,

(s) paraffin oil (sterile),

(t) Butterfield's phosphate buffer,

(u) Kovacs' reagent, and

(v) Voges-Proskauer reagents.

3.8.1. Procedure for the Microbiological Analysis

After the determination of the experiments applicable for the health-care wastes, the laboratory that was convenient for the analysis was identified and procurement of the laboratory was handled. The microbiological analyses were then conducted in Sentez Quality Control Laboratory in İstanbul.

To perform the analyses, samples were collected from the different types of hospitals that were state, private, research, etc. Mostly the hospitals with high bed capacities were selected to gather a well mixture of health-care waste samples. The name of the hospitals that the samples taken from were İstanbul Cerrahpaşa and İstanbul Çapa Medicine Faculty Hospitals, Taksim Training and Research Hospital, Şişli Social Insurance Institution Hospital, Private Yaşam and Bakırköy State Hospital. Approximately 12 samples were taken from the units of medical, emergency, operating, intensive care, pathology and biochemistry laboratories, and blood banks as well as from the temporary storage rooms of the hospitals. Mostly the hospitals with high bed capacities were selected to gather a good mixture of the health-care waste samples. The samples were taken from the units of medical, emergency, operating, intensive care, pathology and biochemistry laboratories, and blood banks as well as from the temporary storage rooms of the hospitals. Masks, gloves and special clothing were used while taking the samples from the red health-care bags to be protected from the infection (Figure 3.8).

The samples were then taken to the laboratory immediately and preliminary study was applied at the laboratory. The next stages that were sample preparation, packaging of test samples, inter laboratory testing, data reporting and evaluation, etc. followed up.

Figure 3.8. The sample taking from the temporary storage rooms of the hospitals.

When the samples were taken to the laboratory, firstly the samples were prepared for the analyses. The representing samples from the gloves, bandages, cotton, plastics, etc. collected from the institutions are prepared by cutting the samples in large size into small pieces by scissor. For the best representing samples, especially the materials contaminated with blood and other infectious agents were selected.

12 samples were prepared with respect to their composition and generation units in the hospitals. While, five samples were analyzed directly as collected from the unit they were taken (only surgery, medical, operating room, etc.), three samples including the specific materials of these samples such as plastics, gloves and bandages were selected and analyzed separately. The rest four samples were the mixture of the samples from the different units and temporary waste storage rooms of the different hospitals.

After this stage, the samples were put in sterile bags and after the addition of 100 ml peptone diluted fluid in each bag. They were closed and labeled as seen in Figure 3.9.

The peptone diluted fluid was prepared by adding 1.25 ml of KH_2PO_4 solution in 1 liter purified water. To sterilize the prepared dilution, it was put in 250 ml bottles and autoclaved for 15 minutes at 121 ^{o}C.

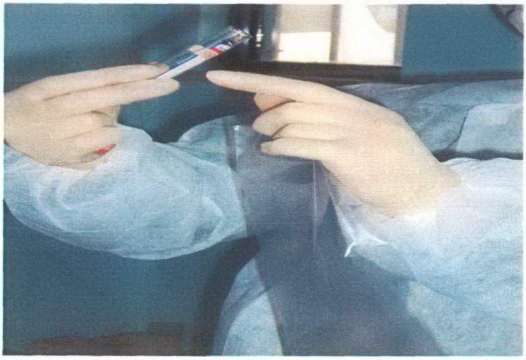

Figure 3.9. The prepared and labeled samples for the analyses.

In the aerobic plate count method which was performed to provide an estimate of the total number of aerobic organisms in a sample, after the preparation of the sample and growing media the decimal dilutions of 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4} were prepared as appropriate by transferring of 1 ml of previous dilutions to 9 ml of sterile diluent to make the sample microorganism capacity accountable as shown in Figure 3.10. The flame of the Bunsen burner was used to provide aseptic conditions to prevent the entrance of the unwanted organisms.

Figure 3.10. Preparation of the dilutions under aseptic conditions.

After labeling all Petri plates, 1 ml of the appropriate dilution of the samples were inoculated (Figure 3.11).

Figure 3.11. Inoculation of the diluted samples.

Samples from each dilution were plated in duplicate or triplicate. The agar medium to be used was melted and then cooled in water bath adjusted to 40-45 °C. Aseptically 20 ml of agar was poured into each plate, and mixed aliquots of sample with agar medium for the uniform distribution of the sample (Figure 3.12).

Figure 3.12. Mixing of the samples with agar medium.

Then the plates were allowed to solidify under room temperature and incubated promptly for 48 hr at 35 °C for the growth of the cultures. The initial and the final stages of the plates are given in Figure 3.13.

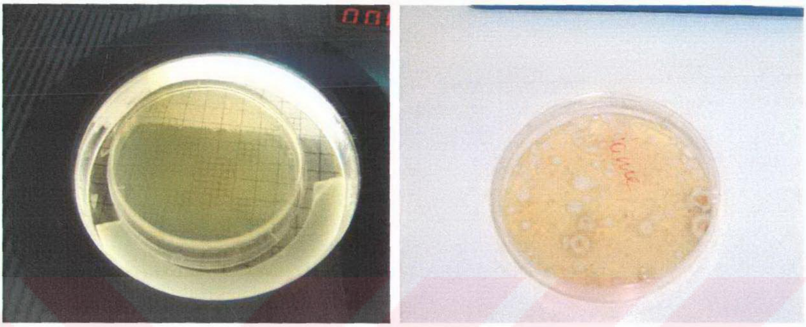

Figure 3.13. The initial and final state of the plates before counting.

At the end of the incubation period, the electronic scanning counter was used for counting the plates, as represented in Figure 3.14. The concentration of cells in the original sample was determined by multiplying the inverse of the dilution factor by the number of cells per ml in the final dilution. The averages of the resulting counts were estimated for the triplicate plating of each dilution.

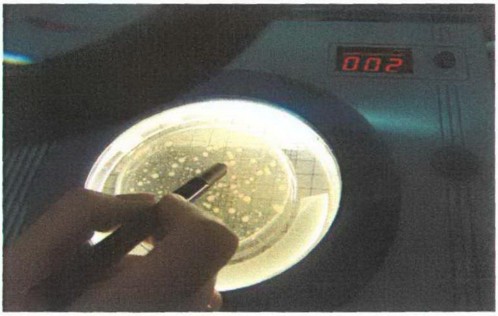

Figure 3.14. The counting of the number of microorganisms in the colony counter.

3.9. Investigation on Waste Minimization

The aim of the following stages was to develop an integrated medical waste management plan for the European Side of the city of İstanbul, based on the possible minimization activities, the establishment of a medical waste collection network and of treatment facilities by site observation, surveys etc. In this stage, based on the classification of the health-care wastes made in the previous phases, firstly the general composition and the average generation of the each type of health-care wastes generated in the European Side of İstanbul was determined.

The main objectives of the waste minimization stage were to identify the wastes that can be minimized, to reduce the volume of these wastes and to prevent the contamination of a large amount of wastes by a small amount of hazardous materials. At this point, the potential of waste segregation at the source was examined and the respective volume reduction of wastes was estimated. In addition to the segregation possibilities, the other activities including waste prevention, reuse, recovery and recycling of the wastes, the alternatives for the product substitution and required process modifications were all evaluated in detail. Based on the data presented, finally a number of policies and practices and suggestion and recommendations with its cost saving were presented.

3.9.1. Program Implementation

For an efficient waste minimization program, firstly the strategy that will be developed by the institutions should be formally approved by top management within the institution as a commitment to the program. Then top management should next assign responsibility to an individual, department head, team, or council. In the European Side, mostly the head nurses were assigned for these responsibilities. The institutions having the waste management team comprised the 36.3 per cent of the total. When management announces the waste minimization strategy and assignment of responsibility, they should include an expectation of cooperation from every operational unit and individual throughout the hospital.

After determining the responsibilities, then the next step should be to gather the data as to the current waste streams being generated within the hospital. These data should include the quantities of waste being generated for each of the waste streams and the costs associated with handling and treatment of these wastes. Unfortunately in most of the health-care institutions in the European Side had no reliable and regular record keeping for the data regarding to the cost and the quantities. This information actually required at the start of the waste minimization project to determine where to initiate the waste minimization strategies as well as to identify the units that wastes being generated mostly. These data will also demonstrate the amount of change that has been achieved from the implementation of the waste minimization, the amount of material being diverted from disposal through reduction, reuse, and recycling activities and consequently the efficiency of the system.

A next step involves training employees on source reduction techniques and encouraging them to develop innovative ideas to reduce hazardous materials usage within the health-care institution. Training should include proper handling and storage of hazardous materials and also include that:

(a) offering incentives to employees to develop new ways to reduce hospital wastes,
(b) annual documentation of the training signed by both the employee and supervisor,
(c) everyone should understand the clear, concise message associated with the program (who is expected to participate, what materials will be reduced, recycled or segregated, why the facility is doing this, when the program will begin and where the recyclable materials goes), etc.

3.9.2. Determination of the Composition in the Waste Stream

As it was mentioned above, in order to successfully reduce or minimize waste generation firstly it should be understood in order why the wastes are generated; where they arise; the special waste handling processes for worker and public safety; regulatory compliance governing the handling of the waste stream; and the varying costs of handling, treating, and disposing of these wastes.

In the institutions, wastes were generated by the various systems and processes within the hospital. Contrary to the popular belief, non-hazardous medical wastes in the institutions makes up nearly three-quarters of the wastes generated in a hospital and should not be overlooked. As it can be seen from the Figure 2.2 presented, more than half of the solid wastes at health-care facilities is paper and cardboard.

In the scope of the study after analyzing the results of the questionnaires, in general; paper represented the largest portion of the health-care institution solid waste stream and was composed of cardboard, craft, high-grade paper, newspaper, magazines, phone books, directories, and other mixed paper. Therefore implementing a hospital-wide mandatory paper recycling policy is a necessity and a few health-care institutions have instituted programs to bale and recycle the cardboard.

The second highest percentage of the health-care institution solid waste stream was organic wastes including yard wastes. The largest component of the organic waste stream from the health-care institutions was food wastes generated from the kitchen. Plastics represented the third highest percentage of the health-care institution solid waste stream. If significant reductions in the solid waste stream were to be achieved, these portions of the waste stream were the leading candidates for intervention strategies.

In addition to the domestic health-care waste, the hazardous waste portion as it was described in the previous chapters included pathological, infectious, pharmaceutical, radioactive and chemical wastes, sharps and pressurized containers. These wastes are normally produced in labor wards, operation theatres, laboratories, medical units, etc. The major types of the health-care waste units of the health-care institutions in the European Side were medical unit, operating theatres, surgical unit and the intensive care unit. From the statistical analysis, the most separated waste types among these units were found as the domestic (96 per cent), sharps (83.9 per cent), infectious (71.8 per cent) and pathological (61.3 per cent) wastes. It was observed that 69.7 per cent of the hospitals recycled their wastes with the average quantity of 15 kg.

Significant reduction of the waste generated in health-care establishments and research facilities may be encouraged by the implementation of certain policies and practices. In the following paragraphs several policies for the accomplishment of a successful waste minimization are summarized.

3.9.3. Reduction at Source

Source reduction involves measures that either eliminate use of a material completely or use the materials generating less waste. It can be accomplished by one of a number of methodologies: change in procurement practices to reduce waste, substitution of a non-hazardous or less hazardous material, process change, improving inventory control, staff training to reduce waste, and/or maintenance of equipment and materials.

Health-care institutions mainly need to focus on generating less toxic waste in the first place. Along with the prevention of the waste generation and recycling, it is important to purchase products made from recycled materials. The policies for the source reduction can also be given as:

(a) improving housekeeping practices to eliminate use of chemical air fresheners (which only serve to mask odors and release toxic compounds such as formaldehyde, petroleum distillates, p-dichlorobenzene, etc.),

(b) replacing mercury thermometers with digital electronic thermometers,

(c) working with suppliers to reduce packing of the products,

(d) substituting a non-toxic biodegradable cleaner for a hazardous chemical cleaner,

(e) finally, rewarding employees for their successful waste reduction ideas.

Packaging reduction is one of the most efficient ways to reduce waste. These efforts typically include ordering items with minimal packaging, requesting reusable/returnable containers, establishing purchasing guidelines to encourage waste prevention, and substituting less toxic materials when possible.

3.9.4. Waste Segregation

Segregation is an important step for minimizing the amount of waste; generating a solid waste stream which can be easily and cost effectively managed through recycling or composting; and reducing the amount of toxic substances release to the environment through disposal of general waste. Segregation of the health-care wastes requires employees to identify hazards associated with the various wastes. If employees are unable to recognize the various waste streams they not only increase the cost of disposal but also increase the likelihood of personal or public injury.

Regulators classify mixed wastes and specify the required manner of its disposal according to the most highly regulated component in the mix. Thus, solid waste mixed with medical waste is classified as medical waste and health-care institutions must dispose all of them as medical wastes. This may increase the cost of disposal by at least 20 times over the cost if the waste streams had not been commingled. The health-care waste that can be minimized by segregation can be summarized as:

(a) used and unused discarded sharps (needles, syringes with needles, scalpels, electro surgical tips, pins, broken glass, pipettes, capillary tubes, glass slides, cover slips)
(b) items so grossly contaminated with blood and tissue that they would produce dripping upon compression (only saturated sponges, dressings, drapes),
(c) items substantially stained with dried blood,
(d) bulk blood and blood products; blood and body fluids in individual containers,
(e) bags and tubing used to transfuse blood and blood products,
(f) microbiological waste (cultures and stocks of infectious agents, discarded live or attenuated vaccines, culture dishes),
(g) tissues, organs, body parts removed during surgery and autopsy,
(h) contaminated carcasses, body parts, excrement, and bedding of animals inoculated with infectious agents, and
(i) wastes contaminated with excretion, exudates or secretions from humans who are required to be isolated in the hospital (to protect others from highly communicable diseases).

The following were suggestions that could lead to an efficient segregation of wastes:

(a) hand washing sinks should have waste containers lined with clear bags rather than red bags, beside them to capture paper towel wastes as solid waste,

(b) every copier and printer should have an appropriately sized recycling bin beside it not a trash can,

(c) every department should have a "battery waste" collection container, this should be plainly labeled and readily accessible so batteries can be properly disposed of either as recyclable or hazardous waste (depending on the type of the battery),

(d) since most of the wastes will either be either solid or recyclable wastes, bags or containers for domestic solid wastes should be located near the metal recycling containers,

(e) the solid waste and medical waste containers should be easily accessible for the staff who use them,

(f) red bags should be placed with careful discretion and responsible personnel must know specifically which containers are supposed to be lined with red bags,

(g) signs and labels should be clearly expressed in addition to universal symbols if possible in Turkish,

(h) labels, signs, and containers should be matched by color for each waste stream,

(i) responsible staff should routinely walk through the floors and review the trash situation by department to find out what is in the containers and what should be,

(j) sharps boxes (made of cadmium free materials) and containers should be used to capture sharps wastes and when these containers are filled, they should be changed out by the responsible staff on a designated schedule,

(k) wherever there is a vending machine, there should be recycling bin beside it which would capture such wastes as aluminum cans, plastic soda bottles, steel cans, etc.

(l) flatten cardboard at the point of generation reduces volume, limits the amount of wasted airspace in collection carts and reduces the number of trips necessary to move materials to the baler, and

(m) the collection container sizes and frequency of pick up should be considered.

3.9.5. Minimization of the Hazardous Materials

The main waste categories that should be minimized for the health-care institutions are chemotherapy and antineoplastics, formaldehyde, photographic chemicals, radionuclides, solvents, mercury, waste anesthetic gases and other toxic, corrosives and miscellaneous chemicals. The suggested waste minimization activities for these wastes are presented in the following paragraphs.

3.9.5.1. Process Modifications and Substitutions. Substituting non-hazardous or less-hazardous materials for hazardous materials can reduce or eliminate the hazardous waste stream. Some health-care institutions have routinely used hepatitis B quaternary disinfectants daily on floors. Infection control specialists have recently directed that this process should only be used for cleaning and disinfecting blood spills, and that daily floor cleaning can be accomplished using floor soap. This process will assist infection control within the health-care institution by reducing the possibility of developing resistant strains of pathogens from the continued use of hepatitis B quaternary disinfectant cleaners. Additionally, this reduces the amounts of chemicals used within the facility and the cost associated with their use (EPA, 1990).

Microanalysis techniques can greatly reduce the amount of waste generated. An example of this is the use of micro-scale chemistry in entry-level teaching laboratories. Also, new equipment can reduce the amount of the waste generated. For example, new high performance liquid chromatography (HPLC) machines use microprocessors to reduce the amount of the waste generated. Professional organizations should be contacted to get information about the latest pollution prevent techniques.

With the some process modifications, hazardous chemicals used and generated can be decreased to lower quantities. Some hazardous materials used in hospitals including the xylene, toluene, ethanol and formalin can be recovered for re-processing and reuse within the hospital environment. Others; silver from x-ray film, mercury, and florescent lamp bulbs and ballasts can be recovered for recycling by an industrial processor.

There is up to 50 times more mercury in hospital and/or medical/infectious waste than in general municipal waste. Items found in waste streams from medical facilities that may contain mercury include glass thermometers and sphygmomanometers, medical batteries, tubing weights, barometers in respiratory therapy and amalgams and finally, small, and potentially overlooked, sources of mercury in the health-care institution are cleaning products. Health-care wastes that contain mercury can be kept out of a medical facility's incinerator-bound waste stream in a number of ways including:

(a) using mercury-free products as an alternative,
(b) diverting mercury-containing products from the incinerator-bound waste stream,
(c) recycling mercury-containing products,
(d) returning mercury-containing products to suppliers, and
(e) replacing barometers with aneroid units

In the product substitution the hazardous wastes are substituted with the non-hazardous or less toxic materials in the chemical processes and experiments. Usage of citric acid based reagents instead of xylene; peracetic acid or cold, physiological saline solutions for formaldehyde where appropriate; usage of detergents and enzymatic cleaners instead of sulfuric acid-potassium dichromate cleaning solutions are the some effective examples to product substitution.

3.9.5.2. Recycling and Reuse. The key practices that can reduce the waste quantities were paper usage, copying and printing only the required documents on both sides of the pages, posting or circulating memos rather than making copies, using e-mail and voice mail to eliminate paper memos, editing documents on screen instead of printing, elimination of the wasteful lunches with excessive packaging, plates, cups, and disposable materials. The reduction activities accomplished in the kitchen, offices, etc. also include a list of practices which are to buy in bulk (e.g. food and drink containers in the cafeteria and soaps and detergents in housekeeping), develop microtesting procedures to reduce chemical usage and to use of physical rather than chemical cleaning methods (e.g. steam disinfection instead of chemical disinfection, etc.

Waste reduction strategies go beyond recycling and should emphasize waste minimization, but recycling and reuse programs are a critical aspect of any waste management and minimization program. Many common single-use disposable products have safe, reusable alternatives including gowns, dishware, utensils, drinking glasses and mugs, batteries by recharging, notebook binders and folders, patient water containers and cups, patient slippers, kidney and wash basins, pillows, dressing trays.

The plastics used in the health-care institutions including the cafeteria plastics, and the medical packaging should be considered for recycling activities. Much of the plastic used in the hospitals is chlorinated, appearing largely in the form of polyvinyl chloride (PVC). Incineration of these materials in the presence of carbon is the major source for generation of dioxins. In order to reduce the exposure risk to these pollutants, the use of PVC as a packaging material in healthcare institutions should be eliminated.

The recycling and reuse activities for the institutions can be summarized as follows:

(a) centralized purchasing of hazardous chemicals,

(b) purchase supplies that are less wasteful or less hazardous,

(c) locate markets for recyclable materials which are generated insufficient quantities, such as office paper, cardboard, glass bottles, food material containers, plastics, solvents (xylenes, toluenes, cfcs), oils (vegetable and hydraulic) and construction and demolition materials such as drywalls, asphalt, concrete, wood,

(d) make a conscious choice to move away from chlorinated paper products, avoiding thus to continue purchasing office paper, paper towels, bathroom tissue paper and napkins that use chlorine in the bleaching process,

(e) explore waste recycling options for food waste either as human food, animal feed either directly or through a commercial processor and as composting or vermiculture and use compost at your facility in landscaping,

(f) reducing the toxicity of waste which also reduces the problems associated with its treatment or disposal,

(g) purchase recycled content material where appropriate (e.g. office paper, envelopes, toilet tissues, paper towels),

(h) use building construction products with recycled materials (e.g. drywall, asphalt),

(i) install silver recovery units for photo processing wastewaters,

(j) evaluate opportunities for anesthetic gas recycling,
(k) recycle healthy placenta,
(l) work with suppliers accepting the return of the oversized packaging materials,
(m) involve ambulatory patients in waste minimization programs, and
(n) use environmentally friendly vehicles and maintenance products (e.g. propane as fuels, rerefined oils, retreated tires, recycled antifreeze).

Important savings for the European Side of İstanbul that can be obtained by the implementation of these suggested waste minimization activities are presented in the Results and Evaluation Chapter.

3.10. Development of a Waste Collection Network

This phase was conducted to develop a health-care waste collection and transportation system for the European Side of İstanbul. Within the scope of the study, transportation of the health-care wastes, the cost-benefit analysis of the existing and the proposed systems for the optimum transportation routes were investigated and the most feasible routes from the point of view of efficiency and economy had been decided. The appropriate system for health-care waste collection was designed by taking into account both environmental and economic issues.

In order to solve the route optimization problem, software programs that consist of MapInfo, Roadnet Transportation Suite Routing and Scheduling Systems were used.

MapInfo Software was used for mapping and geocoding analysis. It provided to create highly detailed maps to enhance presentations and aided in performing sophisticated and extensive data analysis. Roadnet Transportation Suite, which was a combination of Territory Planner, Roadnet 5000 and FleetLoader, shared common modules and a single database and used some of the industry's most sophisticated algorithms, enabling users to create optimized route and load plans. The general screen of the Roadnet is presented in Figure 3.15.

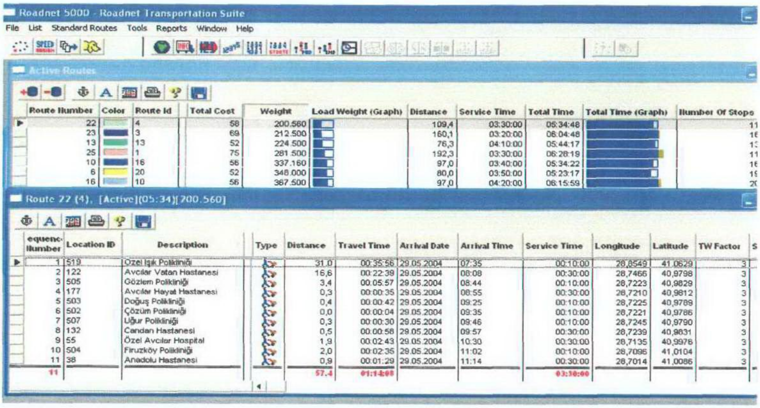

Figure 3.15. One of the screens used in the Roadnet Transportation Suite.

With the Roadnet Transportation Suite, a number of reports including resource utilization, route summary, time and driver performance, stop list and delivery cost reporting were generated. In this program, routes were selected to achieve the shortest transit time along the preferred routes, and the shortest distance for any necessary deviations. The objective of the system was to significantly reduce the kilometers driven, number of vehicles and overtime, a better management of the vehicle capacity, and to reduce the routing time and collection costs, all which means the route optimization.

In order to determine the optimum routes by using the program, the data about the amount of the health-care wastes generated from the hospitals and clinics, estimated loading process time and the capacity of collecting vehicles were obtained. Additionally, locations of proposed solid waste transfer stations for mobile systems, incineration plants, depots of the district municipalities and the location of hospitals and clinics were determined. The existing road and railway network were also taken into account by the map of the European Side of İstanbul supplied by the Municipality.

For determining the feasible routes, it was decided to improve the existing system as an intermediate measure. After the existing system was investigated, different transportation routes have been suggested to reduce the cost arisen from the transportation.

The developed new system aims the transportation of the wastes directly to Kemerburgaz Incineration Plant without any transfer station.

3.10.1. Existing Waste Collection Network

Approximately 20 tones of health-care waste were generated from the 132 hospitals and 241 polyclinics in the European Side of İstanbul and more than 75 per cent of these wastes have been generated from the hospitals. The rest have been generated from the other small health-care institutions including the clinics, private doctors' offices, dispensaries, pharmacies, etc.

None of the hospitals, nor a large number of geographically dispersed clinics in the European Side of İstanbul have any on-site treatment facilities for the health-care wastes and thereby they demand privatized waste management agencies capable of providing collection and treatment services. The wastes from the health-care institutions having more than 20 beds are collected by the licensed company ISTAÇ of the İstanbul Greater Municipality and other authorized agencies and transported to the health-care waste incineration plant in Kemerburgaz-Odayeri directly.

The capacity of the health-care waste incineration plant is a ton of waste per an hour, totally 24 tons in a day and over the ten years more than 60,000 tones of health-care wastes from the hospitals, clinics, dental clinics and private doctors' offices and other small health-care institutions in İstanbul have been disposed of at the Kemerburgaz Incineration Plant (Öztürk and İskenderoğlu, 2002).

The transportation of the health-care wastes from the temporary storage rooms or containers of the health-care institutions to the final incineration area are conducted in two ways. The health-care wastes generated in hospitals are collected and transported to the Kemerburgaz-Odayeri Incineration Plant by the vehicles of the ISTAC. However, the health-care wastes generated in the small health-care institutions are under the responsibility of the district municipalities. Each district municipality is assigned the responsibility of the collection and transportation of the health-care wastes generated within their districts to the Kemerburgaz-Odayeri Incineration Plant.

For ISTAC and the district municipalities, system management should focus on how to collect health-care wastes from the geographically dispersed hospitals. Although the daily collection of the health-care wastes was required, there was not a daily routing schedule for the collection of the health-care wastes from the institutions. The reason is that this requires most of the collection vehicles and laborers, which it is an economic burden for the municipalities.

Usually the collection of the health-care wastes by ISTAC and the district municipalities is conducted on a daily basis if it is stored at room temperature. If stored at a temperature lower than 5°C, such waste can be collected within seven days. But in most of the hospitals health-care wastes can not be stored at this proper temperature, especially in small hospitals where the health-care wastes are collected once a week. As ISTAC and the district municipalities collect the health-care wastes from the hospitals and other health-care institutions once, twice or three times a week, the collection frequency found as not efficient and appropriate according to the current conditions of the health-care waste storage areas.

The efficiency of waste collection is especially weak in outlaying areas and the unplanned settlements of the European Side. In unplanned areas, the collection of waste is especially difficult as most of the roads are too narrow or in very poor condition.

In the collection and transportation of the health-care wastes generated from the hospitals, İSTAÇ have totally 14 vehicles. Eight of these vehicles have the capacity of 2,500 kg and the rest have the capacity of the 1,500 kg.

For the other health-care wastes generated from the small health-care institutions that are not collected by İSTAÇ, each district municipality has only one vehicle allocated for this purpose in general. Although there are 21 districts in the European Side of İstanbul, it is found that, some of them did not collect their health-care wastes as they do not pay any attention to the risk of these wastes or their region and the generated health-care wastes are smaller than the others. These district municipalities made an arrangement with the nearest district municipalities for the collection of their health-care wastes.

Although all of the transportation vehicles of both district municipalities and the metropolitan municipality meet the standards, the operators and handling people of these vehicles do not have the proper training about the job they are conducting. Therefore they should have an intensive training about the subject.

3.10.2. Operating the Software Program

3.10.2.1. Starting of the Program. First of all, according to the postal addresses, location and coordinates of all the points including the hospitals, clinics and depots were determined and by using MapInfo, these coordinates were located on the maps. Thus, 132 hospitals, 241 clinics, 21 depots of district municipalities, two transfer stations and the existing incineration plant at the European Side were geocoded for the computer system.

For using the Roadnet 5000 programme, data about the geocodes, health-care waste quantities, estimated loading process time and work time, and the costs for the vehicles and drivers salaries were loaded. In addition to these, a variety of data such as information on accident rates, transit time, population density and activities, and the day and time during which transport will occur, for the transportation route was also considered.

3.10.2.2. Arranging of the Daily Working Time. The working schedule has additional limitations regarding to the daily working time. Therefore before running the program, the daily working time was determined with respect to the existing practices at the European Side of İstanbul.

For the proposed scenarios, the scheduling for collection was done on a daily basis including the weekends. The working time for a day was accepted as eight hours. Of this, the vehicle working time for the driving was accepted as six hours by considering that the loading and unloading process time of the wastes at the health-care institutions and the depot and the lunchtime of the workers could take approximately two hours. For each vehicle, one driver and one collecting personnel were allocated.

3.10.2.3. Selection of the Vehicle Types and the Capacities. The vehicle types and the capacities were also the parameters that should be established for the system. Three types of the vehicles were selected according to their capacities. These were the large, medium and the small ones with the loading capacity of 2 500 kg, 1 200 kg and 500 kg respectively. The software program gave the optimum number of collection vehicles directly according to each route. According to the carrying weight capacity of the vehicles and workload, the optimum number and types of the vehicles necessary for the health-care waste collection at the European Side of İstanbul were directly determined for each proposed route. It was assumed that the vehicle average speed was 30 km/hr and the loading process took 10 minutes for the clinics, 30 minutes for the hospitals including picking up, unloading and other required procedures such as signing of the waste tracking forms.

3.10.2.4. Cost Settings. In the estimation of the total cost, two parameters, which were the driver salary and the equipment cost were taken into consideration. For these determinations, the questionnaire filled by the district municipalities was evaluated. According to the cost they spent for the personnel salary, vehicle operation and maintenance, firstly the salary of the workers was taken as 25 $ per day. Then, the equipment cost was determined as fixed and variable costs. The fixed cost of the vehicles which were for leasing, purchasing, insurance and license fees were assumed as 17,860 $ for the large, 15,300 $ for the medium and 12,300 $ for the small vehicles annually. Then, the variable costs that were affected by the distance driven, fuel oil, repair, maintenance were accepted as 0.416 per cent, 0.300 per cent, and 0.200 per cent for the large, medium and small vehicles respectively.

3.10.2.5. Running of the Roadnet 5000 System. After inputting all the requirements for the system and after all these estimation and assumptions, the program was run for many scenarios. All these scenarios were analyzed firstly for the collection of the health-care wastes from all health-care institutions together including all the hospitals and clinics and secondly for the collection of them separately as only from hospitals or only from clinics.

In the generation of the scenarios, the main determining parameters that the scenarios based on were the starting and finishing depots of the vehicles.

For each scenario, a single database was developed, the routing path configurations such as locations of the institutions, vehicle capacities and many other options for the routing and scheduling process were set and then the Roadnet 5000 system was ready to run. The system was run for different options to find out the optimum settings to achieve mainly the minimum costs for the collection of the health-care wastes. After this application, several route maps and route itinerary reports were generated.

Color-coded routes, planned route details and individual collection point information were presented in Figure 3.15. This point information than can be seen from the Figure 3.15 included time window graph, arrival time, service time, total time, distance driven, as well as the costs. By double clipping on each route, stop list can also be viewed.

After the running was completed, the program identified the optimum number of vehicles, capacity of the each vehicle, the total collection time, the total costs and the most feasible routes for all the health-care institutions that were input.

In this respect, for the each alternative method and technique as well as the existing methods, the calculation and comparison of the capital investment cost and operational cost were identified and evaluated in Results and Evaluation Chapter.

3.11. Alternative Treatment and Disposal Methods

The health-care wastes generated from the health-care institutions in İstanbul were currently disposed at the Kemerburgaz-Odayeri Incineration Plant directly. Because of the fact that, at the health-care institutions people are not very sensitive in the segregation of the wastes some of the domestic wastes are also incinerated in the incineration plant while some of the infected ones are disposed in the open dumps / sanitary landfills mixed with the domestic wastes. The treatment plant at Kemerburgaz - Odayeri was operating at its full capacity and as the amount of the health-care wastes generated had been increased gradually, the capacity of the plant should be increased to meet the demand.

For these reasons, during this phase, the possible alternatives for the treatment and disposal of the health-care wastes at the mobile or stationery plants were evaluated. Alternative sites were examined and a proposal for the site allocation was effectuated. In determining the appropriate systems, unit and operational costs, applicability to the health-care wastes and efficiency dimensions, working time and the requirements for the electiricity or steam, etc. were evaluated by the use of a cost benefit analysis. The requirements for an efficient system are presented in the following paragraphs about the incineration, sterilization, other thermal treatment, and physical and chemical disinfection methods.

3.11.1. Incineration as the Existing Disposal Method

The health-care wastes generated from the health-care institutions in the European Side of İstanbul are currently transferred directly to the Kemerburgaz-Odayeri Incineration Plant and incinerated (Figure 3.16). This incineration plant was constructed by Ansaldo Bolund Company in 1995 and the investment capital for the plant was 27.000.000 $. Today the cost price for the incineration of one kg health-care waste is 0.4 $ while the generated electricity is 0.5 MW/h. This electricity is used by the establishment at the administrative building, laundry care workshop and for illumination of the environment. The incineration plant has been operating at its full capacity which is 24 tones/day and the required treatment processes defined in the Regulation are exactly followed.

In the implementation of the incineration on the health-care wastes generated from the European Side of İstanbul, there are several problems that should be handled carefully. To start with, one of the main components found in the content of the health-care wastes in İstanbul is the plastic wastes. The presence of plastics in the waste contributes to the emission of heavy metals (e.g. cadmium, chromium or lead, which are added to plastics as stabilizing agents or dyes) and polychlorinated organic compounds which are cancer-stabilizing agents or dyes) and polychlorinated organic compounds which are cancer-causing materials. This is one of the drawbacks of the incineration as the percentage of the plastics is still being increased.

Figure 3.16. The Kemerburgaz-Odayeri Incineration Plant.

Depending on the type of the health service facilities, infectious wastes constitute only 3 to 15 per cent of the total weight of the wastes placed in the red bags. Domestic and recyclable wastes constitute the rest of the total weight because of the inefficient segregation. According to this situation, rather than 3 to 15 per cent of the total weight of the health-care wastes, all the wastes are incinerated.

One of the other important parameter affecting the efficiency of the incinerator is the calorific value of the wastes. At the European Side, the wastes usually have high moisture content and it causes the usage of more additional fuel and consequently high cost.

As the total generated health-care waste in İstanbul (which is nearly 30 tones/day) is not collected daily, the capacity of the existing incineration plant located at the European Side (which is 24 tones/day) is sufficient now. But as these wastes would be collected daily and as the amount of the health-care wastes generated will be increasing gradually, the capacity of the plant should be increased to meet the demand. The high capital and the transportation cost, stringency of the newly accepted emission standards and improved European Regulation of ash disposal lead to revision of the existing incineration plant and evaluation of the alternative technologies for the treatment of the health-care wastes.

In the scope of the study, firstly a construction of an alternative waste incineration plant was examined to increase the current capacity for the future expectations. When it is considered that the amount of the generated health-care waste at the Asian Side of İstanbul is 8,788 kg/day (Kılıç, 2004), the construction of a new incineration plant at the Asian Side will reduce the amount of incinerated health-care wastes at the current one which was located the European Side and thus increase the capacity. Separate collection of these wastes at the Asian Side will also help to decrease the cost arisen from the transportation of the health-care wastes.

To analyze this proposal in detail, the incineration manufacturers were contacted about the cost, efficiency, applicability and the general requirements for the incineration plant. After the evaluation of the information obtained, incineration system was found as applicable to all types of wastes with the efficiency of 90-95 per cent. When the capacity of 8,788 kg/day (which means nearly 400 kg/hour) is considered, the required cost is estimated as 3,000,000 Euro.

Taking these results into considerations, it was concluded that although the price that will be spent for a new incineration plant for the Asian Side and the requirements will be very costly, it is one of the solutions to design an incineration plant at the Asian Side while the current one is also being operated for the European Side of İstanbul.

3.11.2. Mobile Treatment Systems

As the second alternative for the treatment of the health-care wastes, mobile treatment systems were evaluated. Mobile systems are operated based on the disinfection and sterilization of the wastes with pressurized steam at the mobile sterilization vehicle. These vehicles include mainly a shredder unit and special containers resistant to a pressure which is nearly 1,500 mbar for five minutes. The vehicles collect the health-care wastes from the institutions in these containers until the required capacity for the treatment is reached, and then the treatment process is started. In the vehicles, the wastes are firstly shredded in the shredder unit and then treated under the certain pressurized steam for sterilization. The final products obtained at the end of the process are in domestic nature and can be disposed at a domestic sanitary landfill area.

The investigated mobile systems generally have the capacity of 150 kg/vehicle and the total process time to treat this amount of waste is nearly one hour. If the total operation time is accepted as eight hours for a day, it can be calculated that only 1,200 kg of waste can be treated with one vehicle per day. In respect to this value, the required vehicle number is found as 22 for 18,473 kg wastes collected from the health-care waste institutions at the European Side of İstanbul.

When the price for one vehicle, which is between the 400,000-500,000 Euro, and the steam, electricity and water requirements are taken into consideration, the total capital and operational cost for 22 vehicles will be more than 11,000,000 Euro. As the cost for the suggested construction of a new incineration plant is nearly 3,000,000 Euro, and the costs for autoclaves and microwaves described in the following paragraphs are less than the mobile sterilization systems; the cost that will be spent for the mobile treatment systems is found as very costly alternative treatment system for the European Side of İstanbul.

3.11.3. Autoclaves

There are several treatment technologies commonly used in the world including autoclaving (steam sanitation), microwaving, chemical disinfection and ultraviolet treatment. In many technologies, waste is first subject to shredding, mainly in order to increase the contact of the reducing agent with the waste and to decrease the volume of the final output. In the following paragraph, firstly the autoclaves are investigated.

Although the advantages and the low operational cost of the autoclaves with respect to the incineration, the autoclaving method is widely used for recyclable wastes and is not recommended however for the treatment of some types of wastes including the chemotherapy, pharmaceutical, laboratory and pathological wastes.

According to the information gathered from several companies including the Bondtech Corp., Tempico Inc., Hyroclave Systems, etc., main necessities of the system are shredding and a high energy requirement. The investment cost of the system range from 70,000 to 200,000 Euro for the amounts of 90 to 500 kg of waste/hour respectively. The operational cost of these systems is generally 0.1 Euro/kg. For the 18,473 kg of waste generated at the European Side in a day, the approximated cost for the autoclaving is found as nearly 350,000 Euro.

3.11.4. Microwaves

According to the price received from the companies such as Sanitech Inc., Roatan Medical Technologies, Bio Oxidation Services, etc., the price of the system with a capacity of 250 kg/hour is about 400,000 Euro, while the processing costs for 1 kg waste varies from 0.05 to 0.15 Euro. Although microwaving is evaluated as an alternative treatment method to the incineration, microwaving is not sufficient for sterilization at the temperatures above 120 °C.

Even though its treatment cost per kg is much lower than other methods, the microwave treatment methods were another expensive option in terms of the total costs for treatment and disposal of health-care wastes. This due to the presence of health-care waste that is not suitable for the treatment by microwave, but suitable for the treatment by incineration. Thus a large proportion of the wastes that can not be treated by microwaving should be transported to the incineration plant which causes an additional cost as well as the incineration cost at the incinerator.

3.11.5. Other Alternative Treatment Processes

In the scope of the systems, the other alternative treatment processes including the chemical disinfection, disinfection with superheated steam and dry heat, rotoclave and hyrdoclave were also evaluated. In the chemical disinfection, costs depend primarily on the price and availability of the disinfecting agents and shredding equipment. Since the chemical disinfection can only be used for the treatment of the health-care wastes such as infected fluids, sharps and reusable items and not for human and animal remains and chemical wastes, this treatment alternative is not suggested for the European Side.

In the disinfection with superheated steam, the unit works with the steam produced at high temperatures and under atmospheric pressure. The system consists of a shredder and the volume of wastes can be reduced by some 50 per cent. The capital cost of the system is 500,000- 600,000 Euro while the operating cost is nearly 1 Euro/kg.

Although the required space is less than the incinerator, this system is profitable for the hospitals having 250 beds and more and it can only be applied for chemical, infectious and pathological wastes. Similar to the superheated systems, dry heat disinfection is also applicable for only infectious wastes and sharps not for the radioactive, cytotoxic and pathological wastes.

Rotoclaves are the modernized version of the autoclaves. The sterilizing agent is water vapor. Volume reduction of the wastes is around to 50-60 per cent (without shredding) and 80 per cent with grinding. The price of the systems is in the range of 300,000-1,500,000 Euro and the operating cost is approximately 0.4 Euro/kg. Nevertheless, the process can sterilize only laboratory wastes and bedding material.

In the hydroclaves, the process is based on the hydrolysis of organic materials under the influence of dynamic action of steam and temperature. The introduction of the steam is combined with immediate heating up and dehydration of the wastes being mixed (135 ^{o}C). The operation takes about 1 hour. The proper sterilization process takes about 20 minutes. The total wastes can be reduced 80 per cent by volume. The price of the systems ranges from 150,000 to 250,000 Euro and the operating cost approximately 0.1 Euro/kg. This technology can be applied mostly for the infectious wastes and anatomical wastes.

3.12. Designing a Waste Management Structure

Collection and transportation of the health-care wastes both by the metropolitan and the district municipalities and final disposal of them by the metropolitan municipalities prevent the conductance of the health-care waste services efficiently in an integrated manner in İstanbul. In the scope of this stage, to solve the wrong institutional structure and consequently the inefficient management of the resources, a health-care waste management center was proposed. The centre was accepted as the responsible for the operation of the health-care waste management plan (collection network, treatment facility, etc.). In formulation of the management structure, firstly, the needs of personnel were estimated and their role was determined. In the proposed waste management structure, integration of small medical waste generation sources was also provided.

4. RESULTS AND EVALUATION

4.1. The Main Deficiencies and Suggestions for the Regulation

After conducting the field research, the main problems faced in the implementation of the Regulation were determined. When the existing situation was evaluated, it was found out that the Turkish Medical Waste Control Regulation had insufficient content for an efficient health-care waste management both at the institutional and administrative level and it needs a significant revision.

The two major problems observed during the field research were the insufficient knowledge about the Regulation by the health-care institutions and lack of control of the implementation of the Regulation by the Metropolitan Municipality and the Ministries. The other main deficiencies resulting from the Regulation are presented as a list below:

(a) In the Regulation, the health-care waste generating sources include mainly the major generation sources. This item should be enlarged with the addition of the minor sources such as the home health-care treatment, etc.

(b) Definition and classification of the health-care wastes are not clearly stated. This statement should be clarified with the additional types of health-care wastes as the infectious, pathologic, chemical, radioactive, pharmaceutical wastes, pressurized container, waste with high content of heavy metals, genotoxic wastes and sharps as well as the recyclable and domestic wastes. The classification of the health-care wastes made by WHO (explained in Chapter 2) would be a basis for this revision.

(c) The points related to the separate collection of the wastes should be clearly stated as segregation of domestic, recyclable and health-care wastes. The color coding of the waste collection bags should also be properly identified.

(d) In the Regulation, there is not any specific item regarding the recyclable wastes. The classification of the recyclable wastes as serum bottles and medicine vials should be expanded by including the paper, cardboard, plastic, battery, metal wastes, etc.

(e) According to the Regulation, sharp wastes should be crushed with a simple mechanical tool and collected separately in special red plastic bags. This item should be improved by a clear statement for the collection of the sharps in special sharp boxes.

(f) In most of the institutions, it was observed that, instructions given in the Regulation are not clearly understood. The Regulation should also include the necessary instructions that would clarify the required procedures for the management of the health-care wastes and should guide the health-care institutions more effectively.

(g) For the health-care institutions having less than 20 bed capacities, there should be a separate section that will describe the required operations clearly.

(h) The budget allocated for the management of the health-care wastes is very limited and labor allocation is adversely affected by the shortage of financial sources. The Medical Waste Control Regulation does not indicate how the institutions will finance the health-care waste operations according to the Regulation.

(i) For the Regulation, it is suggested to contain obligatory statements for the health-care institutions to assign personnel who are responsible for only the management of the health-care wastes.

(j) Regarding the responsible personnel, there should be a compulsory statement to that they have training and obtain a certificate given by the Metropolitan Municipalities and the Ministries. Personnel who do not have a certificate should not handle the collection and transportation of the health-care wastes.

(k) There should be frequent training programs for both the top management and the personnel involved.

(l) As the most important point, the enforcement and control of the requirements in the Regulation should be conducted.

(m)For the evaluation of the newly adopted European Legislations, a team should be assigned in the Turkish Ministry of Environment and Forestry. With the investigation of these regulations, necessary revision and modification should be regularly accomplished.

4.2. Review of the Existing Situation

In this stage, the sources and the current management practices have been reviewed. Some of the most common problems identified were inadequate waste management, lack of awareness about the health hazards and environmental pollution, insufficient financial and human resources and poor control of waste disposal. The main problems observed during the study were identified under several titles as in the following paragraphs.

4.2.1. Administrative and Financial Problems

(a) In almost all the health-care institutions, top management, hospital managers, head nurses, etc. do not pay any attention to the health-care wastes both because of their insufficient knowledge about the significance of the subject and of their lack of interest. They behave as if the health-care waste handling is not their main duty.

(b) There is not any person assigned as the responsible person in charge of the handling and management of the health-care wastes in most of the health-care institutions.

(c) The people handling of wastes at the institutions are not aware of the legal requirements. The top management either does not obtain the legal documents because of the lack of the authorized person at operations. This case is observed especially at the university hospitals which have many branches.

(d) Personnel assigned by the management of the health-care wastes in many institutions and the responsible personnel involved are also not given adequate training that leaded to inappropriate management and insufficient implementation of the Regulation.

(e) There is not any valid data about the amount and composition of the different types of health-care wastes generated at the health-care institutions. Therefore it is not possible to plan, develop and apply appropriate waste management strategies. As a control body, there is also no effective record keeping on these data by the ISTAC.

(f) Health-care institutions especially state hospitals do not have enough budget and employee to allocate for the health-care waste operations according to the

Regulation and the Regulation does not indicate how the institutions will finance these services.

(g) Because of lack of knowledge and budget, most of the health-care institutions do not also have appropriate bags, containers for the different kind of health-care wastes.

(h) Since there is not any strict control both by the municipality authorities and the hospital management, these services are tried to be conducted by untrained employee at the most cheapest way such as using inappropriate red plastic bags (thinner than 150 micron) which can be damaged very easily.

4.2.2. Problems Arising from the Segregation of the Health-Care Wastes

(a) In many health-care institutions, the authorized manager and personnel are insensitive to the segregation and separate collection of the health-care wastes because of lack of training.

(b) As the classification of the health-care wastes are not described clearly in the Regulation, the personnel dealing with the management of the health-care facilities can not have a thorough knowledge of what chemicals or wastes are considered as infectious. The separation and the storage of these wastes in the units of the institutions could not be managed efficiently.

(c) The appropriate colour coding for different types of wastes and the necessary signs are not provided in most of the health-care institutions. The dust bins for the domestic wastes at the patients' waiting rooms, offices, kitchen, and hospital entrance halls are lined with red bags instead of blue bags. On the contrary the containers in some of the laboratories and the patient treatment rooms are lined with blue bags. So all the wastes including the domestic, infected and recyclables, etc. are collected in the same bags (Figures 4.1, 4.2 and 4.3).

(d) Although infected waste containers as well as sharp boxes should be located in each unit where they might be needed (including operating rooms, emergency services, etc.), in some hospitals only one container is used for several departments.

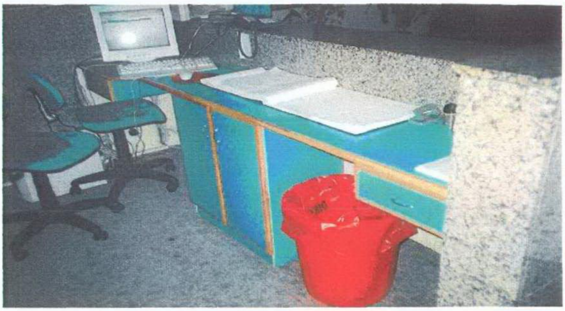

Figure 4.1. Wrong application of the red begs in the offices.

Figure 4.2. Container located in the kitchen including red medical waste bag.

Figure 4.3. Domestic and recyclable wastes in red bags at the waiting room of visitors.

(e) Most of the waste bags used do not have the statement and the logo indicating the medical wastes or have wrong statement on it (Figure 4.4).

Figure 4.4. International medical waste symbol on blue bags having the statement as "Domestic Waste".

(f) Wastes including the infectious material such as pathologic, pharmaceutical and especially the radioactive wastes which should be collected, stored and transported separately are collected and stored in the same bag together with the domestic and recyclable wastes in the health-care institutions (Figure 4.5).

Figure 4.5. Mixture of the bottles, food packages, gloves, etc. in the red bags.

(g) Same situation regarding the segregation is also true for the domestic wastes. Although the colour of the bag is blue or black, the content of these bags can be infectious or hazardous (Figures 4.6 and 4.7).

Figure 4.6. Used infected gloves mixed with paper boxes in blue bags.

Figure 4.7. Patient treatment wastes in the container lined with blue bags.

(h) Although sharps must be deposited in the containers made of a puncture-resistant material (cardboard, plastic, or metal), it is often the case that used sharps, injectors; needles, etc. are placed directly into red health-care waste bags without being deposited in special yellow box (Figure 4.8).

(i) In many health-care institutions, yellow sharp boxes are placed into red waste bags without closing their lids tightly, causing the risks of puncturing the bag. In some cases, injectors are put into glass or plastics serum bottles. These bottles may damage the incineration plant (Figure 4.9).

Figure 4.8. Red medical waste bag including the used needles and sharps without being deposited in special yellow box.

Figure 4.9. Sharps collected in plastic water bottles.

(j) Even though, sharps should be deformed/broken before depositing into the box according to the Regulation regarding the sharps, it is not practiced in any institution as they do not have the deformation equipment.

(k) Although the yellow boxes for sharps are for only one usage and they should be placed in the red bag with the other health-care wastes for the final disposal, most of the hospitals use these boxes over and over because of lack of budget.

4.2.3. Problems Observed During the Transportation within the Institutions

(a) In order to reduce the cost for the collection of the wastes, most of the plastic bags manufactured, which should be made of polyethylene with the thickness of 150 micron and resistant to be punctured during the transportation, do not comply with the requirement. These bags by any struck are torn and their content which may also be infectious can spread to both into container, vehicle and to the environment.

(b) In some health-care institutions, the health-care waste bags are not transported to the storage room on wheeled containers, but by hand through the by using the patients and visitors elevator. The leakage is spreaded on the floors (Figures 4.10 and 4.11).

Figure 4.10. Transportation of the red bag manually with the leakage spreaded.

(c) Although only three-quarters of the red bags should be filled, sometimes it is observed that they have been filled exceeding their capacity.

(d) The necks of these bags are not tied.

(e) The wrong applications of the colour coding can cause risks for the scavengers segregating the recyclable materials. This fact is especially true for the health-care institutions in which no container or waste storage room is present.

(f) Since the segregation of the health-care waste is not applied efficiently, wastes contain every kind of wastes from the radiology department. The risks are inevitable for the workers, patients and the public.

Figure 4.11. Transportation of the red bag manually at the visitor's elevator.

(g) During the transportation of the health-care waste containers within the facility, the containers are not securely closed.

(h) Washing of the health-care waste containers with a disinfectant cleaning solution should be accomplished once a day. The observed containers are usually tarnished, torn and sometimes have holes on it.

(i) Although it is obligatory for the staff to wear heavy utility gloves, special clothes, mask and sturdy shoes during handling health-care wastes, the workers collect the health-care wastes without any precaution (Figures 4.10 and 4.11).

4.2.4. Problems for the Storage at the Temporary Waste Storage Rooms

(a) Most of the health-care institutions have no temporary storage room or container.

(b) Most of the temporary storage rooms are not constructed according to the Regulation. The chamber for the infected wastes sometimes has drainage to the sewer system. They do not have the ventilation system and cooling system for the case that the health-care wastes are going to be stored more than 24 hours.

(c) Temporary storage rooms or containers sometimes have no statement or symbol on them to express their hazardous nature (Figure 4.12).

Figure 4.12. Waste container without any statement or symbol on it.

(d) The bags are placed in front of the storage room instead of placed inside and the doors of the storage rooms are not kept closed providing the entry of any people or animal inside to these rooms (Figure 4.13).

Figure 4.13. Red bag stored in front of the storage room with an open door.

(e) The different coloured bags are stored in the same containers or in the same temporary waste storage rooms although their content are different as domestic, medical, etc. (Figures 4.14, 4.15 and 4.16).

Figure 4.14. Storage of different coloured bags together in the containers.

Figure 4.15. Wrong storage practices in the temporary waste storage room.

Figure 4.16. Storage of different coloured bags together in a waste storage room.

(f) In some health-care institutions, due to the lack of appropriate containers, the bags are deposited anywhere around the hospital. This can be first floor or inside or just in front of the hospital (Figures 4.17 and 4.18).

Figure 4.17. Storage of the domestic waste bags inside of the hospital.

Figure 4.18. Waste bags stored outside of the hospital without any container.

(g) In some health-care institutions, waste storage containers are often placed outside the health-care institutions such as in parking lot, just near the railway, ten minutes distant from the hospitals, etc. (Figures 4.19 and 4.20).

Figure 4.19. Waste containers located on the railway near a store.

Figure 4.20. Medical waste containers located at a car parking lot.

(h) Some of the hospitals use storage containers rather than temporary storage room for the infected wastes. Most of the time the lids of the containers are not closed, and they are located outside of the hospital, they can be used as garbage bin by the pedestrians (Figure 4.21).

(i) Even though health-care wastes containers should be emptied daily or whenever they are three-quarters full, in some containers, health-care waste can be piled up until all the waste are spilled around.

Figure 4.21. Waste container with a bag thrown by the pedestrian.

(j) Although the main principle of the health-care waste storage is not to store the waste on site for more than a few days before final disposal, for some small hospitals, the waste is stored under improper conditions for several days. This waiting period can sometimes be a week until the waste collecting vehicle arrives.

(k) In some hospitals, all the fluid spills including the blood, body fluid and other infectious fluid spills at the temporary waste storage rooms are washed with water and flushed to the environment without any control.

4.2.5. Lack of Control by the Municipalities

(a) The main problem arising from the Municipality is that the control of the hospitals, guidelines and the related documentation are not provided effectively.

(b) Since the penalties given to the institutions by the Ministry are not dissuasive, health-care wastes are not sorted efficiently at the health-care institutions.

(c) There is not any effective record keeping by the ISTAC officers for the quantities and composition of the health-care wastes generated. But, the responsible authorities both in the Municipality and in the Kemerburgaz-Odayeri Incineration Plant should have the record of at least the total amount of waste transferred to the transfer stations for the domestic wastes and to the incineration plant for the health-care wastes.

(d) During the collection of the health-care wastes from the institutions, a document should be received from the health-care institution personnel. This document should include the amount of wastes collected, number and composition of bags, the date of delivery, name of the personnel communicated, etc. But, there is not any regular system regarding this issue.

(e) In many institutions, the health-care waste bags as well as the yellow sharp-boxes are not regularly supplied by the ISTAC.

(f) Collection and transportation of the health-care wastes to the final disposal area which is under the responsibility of the Municipality are not conducted in compliance with the Regulation. The collection frequency and delays arisen from the responsible authorities were observed in many of the hospitals mostly in small health-care institutions. While the health-care wastes are collected daily from some institutions, collection frequency from some other institutions is once a week.

(g) As the appropriate schedule for the collection of the health-care wastes is not existing at the municipality, the generated health-care wastes both in the temporary waste storage room of the health-care institutions and at the final disposal area are deposited at the ambient temperature. These wastes should be kept at a lower temperature if they are not disposed in 24 hours.

(h) No waste is collected from the most of the doctors, dentists' and doctors' offices. They are discarded as domestic wastes, which is a threat to the public health and environment.

4.3. Results of the Questionnaires with the Microsoft Excel Program

In Istanbul Metropolitan Area, there are 197 registered public and private hospitals and 401 registered clinics (KAKAD, 2003). Among these, 132 hospitals (67 per cent) and 241 clinics (60 per cent) are located at the European Side of İstanbul as shown in Figure 4.22.

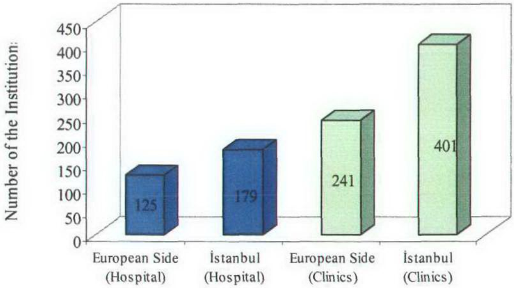

Figure 4.22. Number of health-care institutions in the European Side of the İstanbul.

When the data about the bed capacity of the health-care institutions were evaluated, it was found out that there are 20,864 beds in the institutions located at the European Side. The number of beds and percentage distribution of the health-care institutions in the European Side with respect to their bed capacity is presented in Figure 4.23.

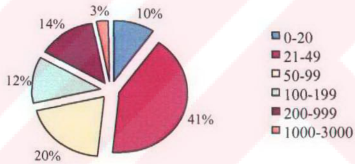

Figure 4.23. Percentage distribution of the hospitals with respect to the bed capacity.

When this figure is examined, it is seen that ten per cent institutions of the hospitals are having the bed capacity in the range of 0-20, 41 per cent institutions in the range of 21-49, 20 per cent in the range of 50-99; 12 per cent in the range of 100-199, 14 per cent in the range of 200-999, three per cent is more than 1,000 beds.

These hospitals are located at the different districts of the European Side as given at Figure 4.24. When this figure was examined, it was seen that the highest number of hospitals (79 of them) are located in six districts which are Şişli, Fatih, Bahçelievler, Bakırköy, Beyoğlu and Gaziosmanpaşa and the rest (53 of them) are located in the other 21 districts (Figure 4.25).

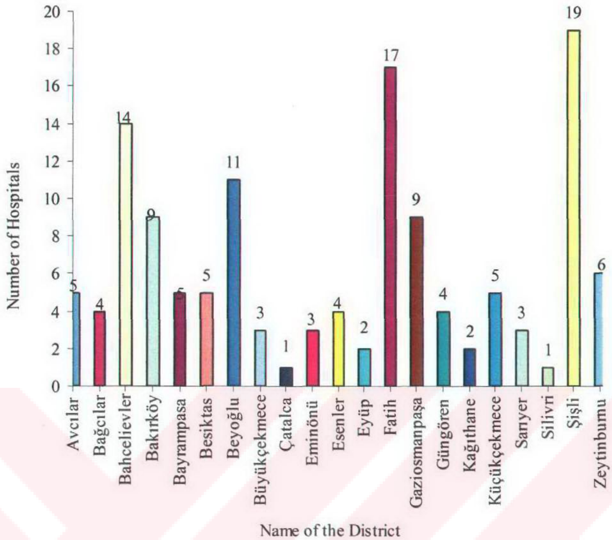

Figure 4.24. Distribution of hospitals at different districts.

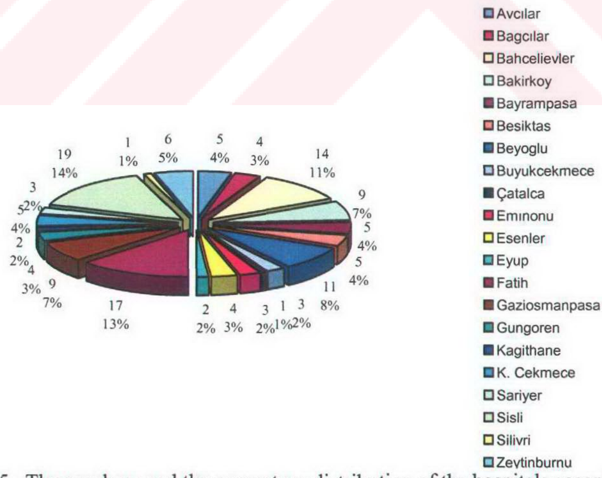

Figure 4.25. The numbers and the percentage distribution of the hospitals according to the districts in the European Side of İstanbul.

The hospitals in İstanbul are administrated under different authorities. They are categorized as the State Health-Care Institutions administrated by the Ministry of Health; Social Security Hospitals administrated by the Ministry of the Social Security and Welfare; the University Hospitals, mainly educational and research oriented, administered by the University they belong to, Military Hospitals administrated by the Ministry of Defense and the private health-care institutions. In the scope of the questionnaires, the hospitals were evaluated under the categories as state, private, research, university, military hospitals and social insurance institutions hospitals.

When the hospitals are categorized with respect to their administrative authorities, 75 per cent (99) of them are private hospitals, 12 per cent (16) are state hospitals, 3 per cent (4) are research hospitals, 5 per cent (7) are social security insurance hospitals, 4 per cent (4) are university hospitals and 2 per cent (2) are military hospitals. The distribution of the hospitals in the European Side according to the administrative categories was shown in Figure 4.26.

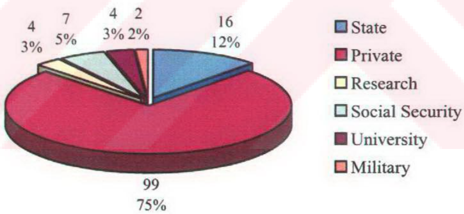

Figure 4.26. The numbers and the percentage distribution of the hospitals according to the administrative categories in the European Side of İstanbul.

When the total bed capacity of the institutions are compared with respect to their administrative authorities, it is observed that 29 per cent (6,023 beds) are at the private hospitals, 20 per cent (4,187 beds) are at the social security hospitals, 19 per cent (3,943 beds) are at the research hospitals, 17 per cent (3,546 beds) are at the university hospitals, 12 per cent (2,560 beds) are at the state hospitals and 3 per cent (605 beds) of them are at the military hospitals. This data and the distribution of the bed numbers at the European Side is presented at Figure 4.27.

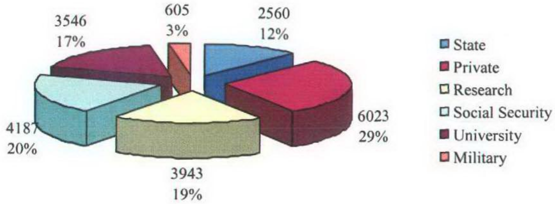

Figure 4.27. The numbers and the percentage distribution of the bed capacity according to the administrative categories of hospitals in the European Side.

When the bed capacity of the European Side of İstanbul is compared with the total bed capacity of Turkey (Figure 4.28), it is seen that European Side of İstanbul constitute 11 per cent of the total bed capacities in Turkey.

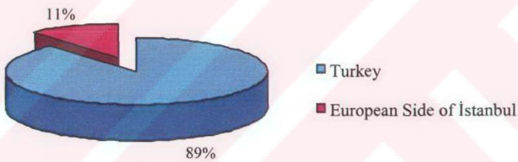

Figure 4.28. The distribution of the bed capacities between Turkey and the European Side.

The percentage of the number of in-patients and out-patients visited the hospitals daily are indicated at Figure 4.29.

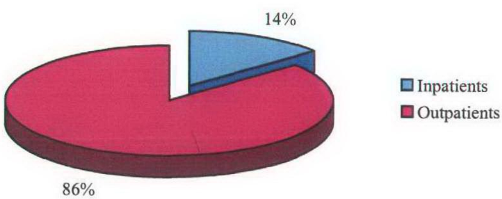

Figure 4.29. Percentage of patients in the hospitals in the European Side.

There had been no statistical record or any reliable data about the amount of the generated waste and its composition neither at the institutional level nor in total in İstanbul before 1995. The change in the amount of the generated healthcare wastes from 1995 to 2001 in İstanbul is presented in Figure 4.30 (Öztürk and İskenderoğlu, 2002).

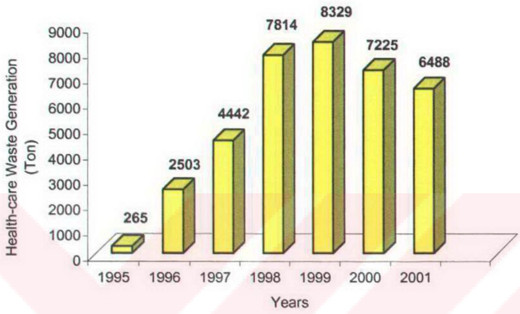

Figure 4.30. The quantity of collected health-care wastes in İstanbul between 1995-2001(Öztürk and İskenderoğlu, 2002).

The distribution of the health-care wastes generated daily from the hospitals and clinics at the European Side in 2004 is given at the Figure 4.31.

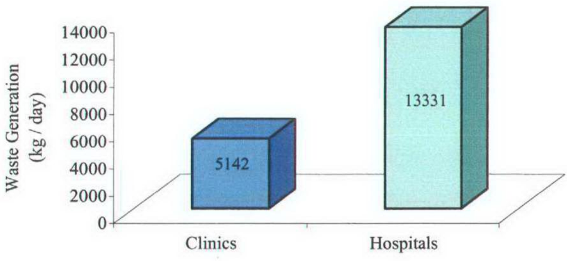

Figure 4.31. Distribution of the generated health-care wastes from the hospitals and clinics at the European Side.

The amount of the different types of wastes as domestic, recyclable and medical wastes at the European Side is presented at Figure 4.32. When this figure was evaluated, it is seen that almost 35 per cent is infected and hazardous wastes which indicates the importance of the medical wastes in the development of the waste minimization strategies.

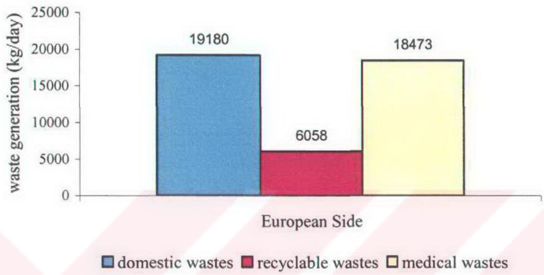

Figure 4.32. Amount of wastes generated in health-care institutions at the European Side.

The distribution of the amount of the health-care wastes generated by the institutions at different districts is given at Figure 4.33. When this figure is examined, it is seen that among all the districts, health-care wastes are generated mostly in the Fatih. Şişli, Bakırköy, Bahçelievler and Bakırköy are the districts that follow the Fatih District.

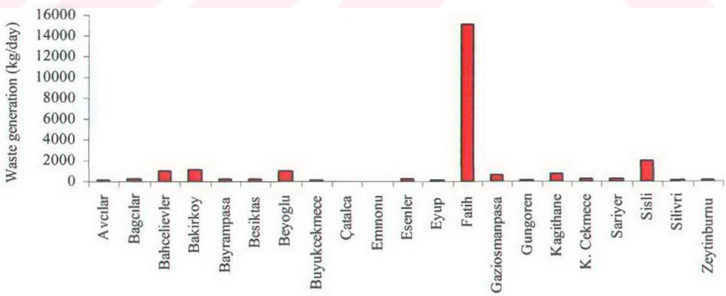

Figure 4.33. Distribution of the amount of the health-care wastes generated by the institutions at different districts.

The amount and percentage distribution of the health-care wastes generated by the institutions at different categories is given at Figure 4.34. When this figure is examined, it is seen that 41 per cent of the wastes have been generated by the private hospitals (which is the 75 per cent of the total institutions).

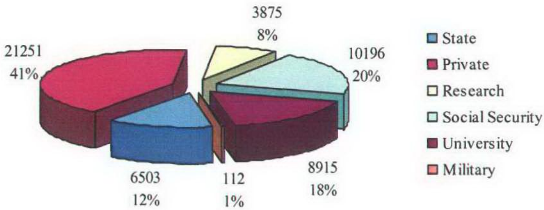

Figure 4.34. Amount and percentage distribution of the health-care wastes according to the administrative categories of the hospitals (as kg/day).

The percentage distribution of the composition (component) of the health-care wastes are presented at Figure 4.35. According to this figure, health-care waste generated at the European Side consists mostly of domestic (50 per cent), infectious (17 per cent) and recyclable wastes (16 per cent). The contribution of especially pharmaceuticals, pressurized containers and radioactive wastes to the total quantity is almost insignificant (Radioactive wastes are handled by the Atomic Energy Commission according to the related regulations).

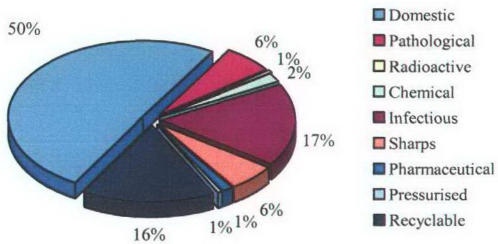

Figure 4.35. Percentage distribution of the health-care wastes according to their composition.

By using the bed capacities of the health-care institutions with respect to the administrative categories, the composition and the average waste generation of the health-care wastes generated was also calculated and the results are presented in Table 4.1.

Table 4.1. Average daily production of health-care wastes generated from the health-care institutions in the European Side of İstanbul

	European Side	
Type of Waste	**Average Production (kg/bed/day)**	**Percentage**
Domestic	2.288	44.05
Pathological	0.422	8.12
Radioactive	0.015	0.29
Chemical	0.106	2.04
Infectious	0.757	14.57
Sharps	0.383	7.37
Pharmaceutical	0.108	2.08
Pressurized containers	0.042	0.81
Recyclable	1.073	20.66
Total	5.194	100.00

When the sources of the wastes were evaluated, the main sources generating health-care waste were analyzed under three categories which were the patient services, laboratories and support services. The percentage distribution of the health-care wastes according to these units is given in Figure 4.36. This figure indicates that the patient services which include medical treatment units, operation and surgery rooms, intensive care, emergency rooms, etc. were the main units generating most of the infectious and the pathological wastes than the remaining departments of the institutions.

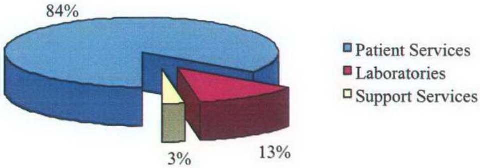

Figure 4.36. Percentage distribution of the of the health-care waste generation with respect to generation sources.

4.4. Results of the Questionnaires with the SPSS Pack Program

At the end of the statistical analysis, the significant findings from the frequency tables are given below:

(a) the units of the institutions which had almost no health-care waste generation are isolation ward, dialysis and oncology units, autopsy rooms, nuclear medicine and hematology laboratories as well as the long term health-care units,

(b) when the patient services are examined, the medical unit, operating theatres, surgical unit and the intensive care unit are the major sources for the health-care waste generation respectively,

(c) the waste generation in the laboratories roughly occurred only from the biochemical laboratories,

(d) in the support services, domestic wastes are mostly generated from the kitchen, administration offices and laundries respectively; from the engineering, there is almost no domestic and recyclable waste generation,

(e) the most separated waste types are the domestic (96 per cent), sharps (83.9 per cent), infectious (71.8 per cent) and pathological (61.3 per cent) wastes,

(f) the percentage of the institutions which have no radioactive waste generation is 94.4 per cent, which is 87.1 per cent for the pressurized container and 59.7 per cent for the pharmaceutical wastes,

(g) 69.7 per cent of the hospitals recycled the wastes and the average quantity of the wastes recycled is 15 kg with the percentage of 5.7.

(h) in the dental clinics and the dental units of the institutions, the most generated wastes are mostly general and iron containing wastes from the mouth, chin care, laboratories and conservative tooth care practices respectively, and

(i) from the ortodonti and pedotonti units, there is almost no health-care waste generation.

When the awareness of the institutions regarding to the any legislation application to the health-care waste management is taken into account, the results are as follows;

(a) 63.7 per cent of the institutions is not aware of the Medical Waste Control Regulation, this was 86.3 per cent when the Hazardous Waste Control Regulation was asked,

(b) the most well known documentation by the institutions is the Guideline on the Medical Waste Management of ISTAC by 64.5 per cent,

(c) while 40 per cent of the institutions have their waste management plan and strategy, only 25 per cent of them have the minimization target in their own strategies,

(d) 36.3 per cent of the institutions have the waste management team, but in only 11.3 per cent of these institutions, the management teams evaluate the waste management performance of their institutions,

(e) in 41.1 per cent of them, there are certain job descriptions for the health-care waste management responsible,

(f) the institutions assigned the health-care waste responsible person is 89.5 per cent; among these 30.6 per cent is head nurse, 21.8 per cent is hospital manager, 12.1 per cent is head doctor, 9.7 per cent per cent is nurse and the remaining are manager assistants and housekeeping personnel,

(g) the education level of the responsible personnel is mostly the upper lycee on health and occupation with 41.1 per cent, the personnel graduated from the university is found as 12.9,

(h) the most observed personnel experience about the management of the health-care waste is one to two years and the training frequency of these personnel is once every six months with percentage of 71.8, and

(i) in the institutions, 77.4 per cent have the required specifications like the special clothes use, etc.

From the point of waste segregation and waste storage;

(a) 52.4 per cent of the institutions have temporary waste storage room while the 38.9 per cent have containers,

(b) the institutions that have no waste storage places are 8.9 per cent, and

(c) among the waste types generated from the institutions, most segregated waste types are domestic (78.2 per cent of total) and sharps (75.8 per cent of the total); this percentage is 12.1 for the radioactive wastes and 6.5 for the pressurized containers.

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(d) 36.3 per cent of the institutions have the waste management team, but in only 11.3 per cent of these institutions, the management teams evaluate the waste management performance of their institutions,
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(f) the institutions assigned the health-care waste responsible person is 89.5 per cent; among these 30.6 per cent is head nurse, 21.8 per cent is hospital manager, 12.1 per cent is head doctor, 9.7 per cent per cent is nurse and the remaining are manager assistants and housekeeping personnel,
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(c) among the waste types generated from the institutions, most segregated waste types are domestic (78.2 per cent of total) and sharps (75.8 per cent of the total); this percentage is 12.1 for the radioactive wastes and 6.5 for the pressurized containers.

When all these findings were analyzed with respect to the administrative categories of the health-care institutions, the results presented below were revealed:

(a) the wastes are recycled mostly in university hospitals (75 per cent) and this is followed by the private and research hospitals (50 per cent each),

(b) the segregation rates of the sharps from the health-care waste stream is accomplished largely in the private hospitals(87 per cent of total sharps) and state hospitals (82.4 per cent),

(c) while the Turkish Medical Waste Control Regulation is well known mostly by the research and social insurance institutions (75 and 71.4 per cent respectively), for the Guideline of ISTAC the private hospitals is in the first rank with the percentage of 71.7,

(d) the university (50 per cent of total) and the private (47.8 per cent of total) hospitals are the institutions that mostly developed their own waste management plans whereas in the state hospitals, the percentage of having waste management plan is 5.9 per cent among all the state hospitals,

(e) when the education level was taken into consideration, private hospitals have mostly educated personnel responsible for the health-care wastes,

(f) in all types of the institutions, the waste handling is mostly carried by the hospital staff rather than a private company, and

(g) the construction of the separate temporary waste storage rooms is mostly accomplished in social insurance institutions and state hospitals, whereas in the research institutions, for the storage of the health-care waste the container usage was the most.

Just like this, many comparisons were made by using the Pearson Correlation to analyze the first part of the questionnaire and the variables that were found having a relationship between each other which means variables that affect each other are:

(a) number of doctors and number of nurses (P=0.889),

(b) number of doctors/nurses and patients number (P=0.981, significant relationships),

(c) number of doctors/nurses and number of bed capacities (P= 0.720),

(d) number of patients and the bed capacities (P= 0.975, significant relationships),

(e) number of sanitation personnel and number of inpatients (P=0.749), and

(f) number of managerial personnel and the number of outpatients (P=0.788).

All the other results obtained from the Chi-Square Analysis and T-Test are stated below. The variables that had the relationships between the each other can be given as:

(a) having a waste management plan and the waste handling performance (P=0.07),
(b) having a waste management plan and the training frequency (P=0.28, significant relationship),
(c) the training frequency and accomplishment of waste minimization (P=0.06),
(d) personnel training and usage of the special clothing required (P=0.41, significant relationship),
(e) personnel training and waste segregation (P= 0.86, significant relationship),
(f) having a temporary waste storage room and knowledge about the Guideline of ISTAC (P=0.15),
(g) the training frequency and the Regulation or Guideline of ISTAC (P=0.09),
(h) having a waste management team and waste management performance (P=0.05),
(i) training frequency and the waste management plan (P=0.06),
(j) having a certain job description for the health-care waste personnel and waste management performance (P=0.07),
(k) having a certain job description for the health-care waste personnel and accomplishment of waste minimization (P=0.07), and
(l) the education level of the top responsible personnel and training frequency (P=0.77, significant relationship).

The variables that had no relationships (P<0.05) contrary to popular belief were:

(a) the education level of the responsible and the waste management performance,
(b) the education level of the responsible personnel and the waste segregation,
(c) having a temporary waste storage room and knowledge about the Regulation,
(d) having a special clothing required and knowledge about the Regulation, and
(e) having a special clothing required and knowledge about the Guideline of ISTAC.

During the classification of the health-care institutions by discriminant analysis, two different functions are revealed. According to these formed functions, the similarities of the types of the health-care institutions between their own categories and between each other are presented in Figures 4.37 and 4.38.

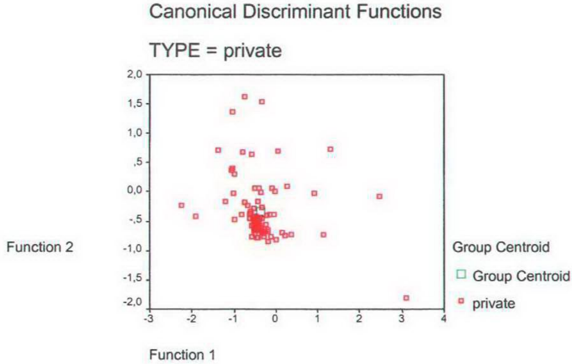


Figure 4.37. The classification of the private hospitals according to the similarities regarding to the health-care waste management.

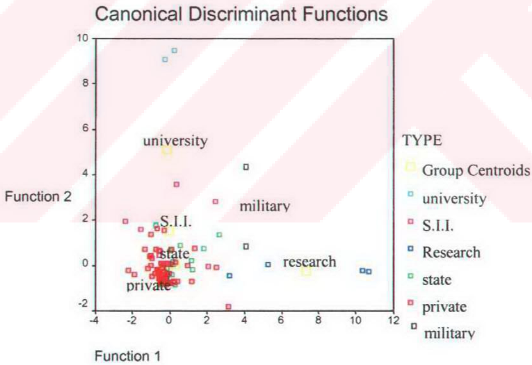


Figure 4.38. The classification of the health-care institutions according to the similarities regarding to the health-care waste management.

From the Figure 4.37 and 4.38, it can be observed, that the private hospital (which were red coloured) are very close to each other in their structure and they have almost same policy with regard to the health-care waste management practices. On the other hand, the research hospitals (the ones coloured with blue mark) are very far from each other with respect to their health-care waste management strategies.

The analyses of the findings also showed that although the types of the hospitals show some similarities with each other, university hospitals (yellow coloured) have almost no characteristics in common regarding to the other types of the hospitals.

When determining the best grouping of the units by cluster analysis, the most determining parameters in grouping the units in the health-care institutions were found as infectious, pathological and domestic wastes. The contribution of each health-care waste types in this grouping was examined according to the significant value of 0.05. On the other hand, it was shown that the variables which were pharmaceutical and radioactive wastes and pressurized container had no significant impact in determining the groups. After the implementation of the cluster analysis, the best number of groups was found as five. Therefore the health-care institutions were grouped under five clusters according to the waste quantities they generated.

When the waste quantities and the type of waste generated were taken into consideration, first group included only the medical unit while the second group included the surgical unit and emergency services. Third group consisted of operating theatres and intensive care units. The biochemical and research laboratories, dialysis units, laundries and kitchens formed the fourth group. Finally, all the remaining units which had the similar waste quantities and waste generation types including the isolation wards, oncology units, autopsy rooms, microbiology and nuclear medicine laboratories made up the last group.

4.5. Results of the Laboratory Analysis

At the end of the laboratory analyses, all the findings obtained from the pure samples and mixed samples are given in Tables 4.2 and 4.3 respectively. When the results of the analyzes are compared, the findings revealed that;

(a) At the results of the analysis, it was seen that the most existing microorganisms in the samples among the other organisms was the total coliform microorganisms. Total coliform microorganisms were mostly generated in the operating rooms. When it is thought that the approximately 6,500,000 unit /1 g coliform microorganisms can cause several infections and considered as a high value. The obtained values 95,000,000 unit/ 1g at the operating rooms as well as the pathology and surgical units indicate that they are significant infection causing agents in those institutions.

(b) Some of the microorganisms which are Salmoneela spp. and Leginella expected to cause an infection were not present in all the collected health-care waste samples.

(c) At the end of the analysis, Enterobacter could not be determined in the mixed samples. Whereas, in especially the samples taken from the intensive care unit and pathology laboratory, the values of Enterobacter (which is approximately 2,000,000 unit/1 g) are found higher than the generally acceptable value of 5,600 unit/1 g.

(d) For the Bacillus Cereus, 57,000 unit/1 g is the commonly faced value at the hospitals, but the analysis for Bacillus Cereus showed that this value can reach even to 8,000,000 unit/1 g at the intensive care units which indicates the highly contamination of the health-care wastes.

(e) Yeast and Moulds analysis was also among the parameters found higher than the acceptable values. Generally saying, these microorganisms are at the level of 11,000 unit/1 g at the health-care institutions. But in the study, some of the calculated values for the Yeast and Mould organisms were 15,000,000 unit /1 g for the pathological laboratories and as a second highest value, 336,000 unit /1 g for the surgical unit. For the rest, there is no significant contamination.

(f) Among all the parameters analyzed, Escherichia Coli and Pseudomononas were found at the acceptable quantities with a few exceptions.

(g) At the end of the analyses, all the remaining samples had reached to the anaerobic conditions. During the analysis of the samples and until the time that the analyses were finished, it was observed that reproduction of these microorganisms continued. Reproduction was considerably much especially at the samples containing liquid in comparison with the others.

(h) Contrary to the popular belief which was that the reproduction was high in the materials that were contaminated with blood, the reproduction of the popular microorganisms were very few in the protective materials such as gloves, plastics and bandages contaminated with blood. Whereas a serious reproduction of these microorganisms were determined in the materials stored in temporary waste storage room, especially the ones containing tissues.

Table 4.2. The results of microbiological analysis for pure samples

The colony count analyze parameters	Results							
	No:1 Patology Laboratory	**No: 2 Blood Bank**	**No:4 Operating Room**	**No: 4 Surgical Unit**	**No.5 Intensive Care**	**No: 6 Plastics**	**No: 7 Gloves**	**No: 8 Bandages**
Total coliform microorganism, unit/1 g	47,000,000	270,000	95,000,000	45,000,000	27,000,000	930,000	1,500	2,500,000
Total coliform bacteria, unit/1 g	600,000	600	83,000	228,000	1,450,000	760	16	80
Escherichia coli, unit/1 g	480,000	15	60,000	61,000	600,000	380	4	12
Enterobacter, unit/1 g	1,750,000	400	1,500,000	-	2,150,000	0	0	0
Pseudomonas spp., unit/1 g	500	60	10	1,256,00	5,000,000	0	0	0
Staphylococcus aureus, unit/1 g	4,750,000	380	3,500,000	5,780,000	7,800,000	270	200	0
Bacillus cereus, unit/1 g	430,000	20	70,000	755,000	8,000,000	0	0	0
Salmonella spp, unit/25 g	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
Legionella, unit/50 g	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
Yeast and Moulds, unit/1 g	15,000,000	800	12,500	336,000	36,000	75	0	2

Table 4.3. The results of microbiological analysis for mixed samples

The Colony Count Analyze Parameters	Results			
	No:1	No: 2	No: 3	No: 4
Total coliform microorganism, unit/1 g	8,760,000	5,800,000	12,000,000	45,000,000
Total coliform bacteria, unit/1 g	435,000	950	7,500	228,000
Escherichia coli, unit/1 g	81,000	80	2,250	61,000
Pseudomonas spp., unit/1 g	558	6,000	60	1,256,000
Staphylococcus aureus, unit/1 g	2,300,000	120,000	1,700,000	5,780,000
Bacillus cereus, unit/1 g	152,000	14,000	90	755,000
Salmonella spp, unit/25 g	Negative	Negative	Negative	Negative
Legionella, unit/50 g	Negative	Negative	Negative	Negative
Yeast and Moulds, unit/1 g	895	760	400	336,000

As a conclusion, the results of the analyses show that many infectious microorganisms are present in the health-care wastes. The contamination found as linear with respect to time which means by the time, the microorganisms can easily be increase by reproduction while they are at the units of the institutions and the temporary waste storage rooms. Therefore it is suggested that with the certain compounds preventing the reproduction of the microorganisms, the health-care wastes should be effectively sterilized. However, sterilization is never absolute; it effects a reduction in the number of microorganisms by a factor of more than 106 (i.e. more than 99.9999% are killed). It is therefore important to minimize the level of contamination of the material to be sterilized.

4.6. Cost Savings from the Waste Minimization Activities

According to the WHO average waste production, it was concluded that the health-care wastes produced in the European Side of İstanbul are within the range of the Western Europe. However, the percentage of pathological, infectious, chemical, pharmaceutical and sharps waste is greater in the case of Istanbul. This could be due to the improper and inefficient management practices in the health-care institutions. It is a fact that a good waste minimization program and practice should be initiated.

The observations at the field studies showed that a proper waste segregation was not applied in most of the health-care institutions. Infectious wastes and domestic wastes were mixed partly. The percentage of the recyclable materials could be more than 69.7 per cent of the total if they were segregated carefully from the domestic wastes.

From the field research it was observed that sharps were usually mixed with the other types of health-care wastes, therefore the use of sharp-boxes should be encouraged. By carefully segregating the waste according to the degree of infectiveness, a health-care institution with approximately 1 300 beds can manage to reduce substantially the infectious wastes saving 65,000 Euro/year

Important savings can be reached by reducing the usage of one-way instruments, already used in the health-care institutions, and replacing them with reusable ones. For example, by using a reusable instrument for laparoscopic operation of gall bladders, the cost savings will be 400 Euro/operation. Similar to this, by eliminating the plastic shoe covers, which are considered as without hygienic importance, a health-care institution having 1,800 beds, and using 130,000 pieces/year of these shoes (which is almost one ton) could save 3,000 Euro annually.

By the training of the waste handling people, the separate collection system in the health-care institutions, cost reduction arisen from the health-care waste management systems can be realized much more efficiently. According to the estimations, in the first year of the application of the waste minimization practices in the European Side, the amount of the infected wastes will be reduced drastically (at least 50%). The pathological wastes and sharps will be the next highest types of the generated wastes.

With the 50 per cent reduction, the fee paid by the institutions to the ISTAC for the transportation of these wastes will also be reduced. Today, institutions pay 0.17 Euro plus VAT per one kg (which equals to 0.21 Euro with VAT) to the ISTAC as the cost of the transportation. When it is thought that for the reduction of 1,000 kg waste, an institution will save 210 Euro/day, by the 50 per cent reduction which means the reduction of approximately 9,000 kg of wastes, the saving of the institutions will be 1,890 Euro/day.

When the routing and transportation cost of these health-care wastes were taken into account, by the 50 per cent reduction, the cost spent for the transportation would also be reduced. While for the amount of 18,473 kg of wastes, the cost was 1,358 Euro (gathered from the routing stage), by the reduction of this amount to approximately 9 000 kg, the cost would be 805 Euro.

By the 50 per cent minimization in the generated waste quantity, also the capacity of the existing incineration plant will be increased. Although, the disposal costs for one kg is 0.35 Euro at the Kemerburgaz Incineration Plant right now, at the end of the waste minimization activities, this cost can easily be reduced to nearly 0.175 Euro per kg too.

4.7. Results of the Waste Collection Network

In order to reach the best solution to solve the routing problem, many options were performed as each option affects the routing differently. Therefore as one of the parameters affecting the cost, initially, the loading process time was determined. As the first alternative, all the scenarios were run by taking the loading process time as 10 minutes for the collection of the health-care wastes from the institutions. This value was applied for both the hospitals and clinics. In the second alternative, 10 minutes for clinics and 30 minutes for hospitals were accepted as the loading time.

In the comparison of the results obtained from the first and the second alternatives, the load weight, number of hospitals and clinics and the working time were naturally the same in both cases. Whereas the required vehicle number in the first alternative was found less than the second alternative as the loading time was accepted 10 minutes rather than 30 minutes. Consequently, the collection costs were lower in the first case than the second one. But in spite of this lower collection cost, it was observed that 10 minutes was not enough for the loading process in the hospitals. So, in all the scenarios, the loading process time was arranged as 10 minutes for clinics and 30 minutes for the hospitals and then the programme was run again.

The results of the each scenario were discussed and compared with each other, and the findings were summarized briefly in the Tables 4.4, 4.5, 4.6 and 4.7. In the tables; vehicle, route number, total collection time, loading weight and the total cost were considered as the most determining parameters.

In the first scenario, the existing waste collection network was transferred to the maps. As no transfer stations were allowed as an interim stage, Kemerburgaz-Odayeri Health-Care Waste Incineration Plant was accepted as the starting and finishing location for the collection vehicle routing. This scenario included the cost arisen from the collection at the Asian Side as well as the European Side. Although currently, the health-care wastes from the hospitals and clinics were collected separately, for reliable and optimum cost estimation, jointly collection of these wastes was also revealed. The results of the first scenario which reflected the current situation is given in Table 4.4.

Table 4.4. The existing collection network of the health-care waste

Scenario 1	**Separate Collection**			**Together Collection**
(Current Situation)	**Hospitals**	**Clinics**	**Total**	**Hospitals and Clinics**
Vehicle number	24	18	42	40
Total time (Hour)	143.35	110.00	253.35	241.30
Load weight (kg)	23 309	6 965	30 274	30 274
Total cost (US $)	1,598	1,123	2,721	2,559
Cost (US$/kg)	0.068	0.161	0.089	0.084

The second scenario was created as an alternative to the existing situation which is presented above. Kemerburgaz-Odayeri Incineration Plant was again accepted for the starting and finishing location for the European Side and the results of this optimum collection in comparison with the existing one are stated in Table 4.5.

Table 4.5. The alternative collection network of the health-care wastes

Scenario 2	**Separate Collection**			**Together Collection**
(Separate Collection)	**Hospitals**	**Clinics**	**Total**	**Hospitals and Clinics**
Vehicle number	15	10	25	25
Total time (Hour)	92.43	62.53	155.36	152.11
Load weight (kg)	13,331	5,142	18,473	18,473
Total cost (US $)	950	641	1,591	1,547
Cost (US $/kg)	0.071	0.12	0.086	0.083

When the results of Tables 4.4 and 4.5 are compared, it can be shown that the collection cost per one kilogram of waste is 0.089 $/day in the first scenario for the current separate collection, whereas it is reduced to 0.03 $/day in the second one which is the suggested together collection.

Third scenario was created for the mobile sterilization treatment system. As by the mobile systems, the sterilized waste obtained at the end of the treatment process was in the nature of domestic waste and can be disposed to the sanitary landfill; in this scenario existing solid waste transfer stations was used. Therefore Baruthane Solid Waste Transfer Station was accepted for the starting and finishing locations for the collection vehicle routing at the European Side of İstanbul. The calculated route results of the mobile sterilization treatment system are given in Table 4.6.

Table 4.6. The mobile sterilization treatment system for the collection vehicle routing

Scenario 3	**Separate Collection**			**Together Collection**
(Mobile Collection)	**Hospitals**	**Clinics**	**Total**	**Hospitals and Clinics**
Vehicle number	13	9	22	22
Total time (Hour)	80.36	54.50	135.26	130.08
Load weight (kg)	13,331	5,142	18,473	18,473
Total cost (US $)	686	480	1,166	1,146
Cost (US $/kg)	0.051	0.093	0.063	0.062

In the third scenario both together and separate collection of the wastes from the hospitals and clinics, the collection cost per one kilogram of waste is nearly 0.06 $. When the results of the first, second and third scenarios are compared, the third scenario, which is the mobile sterilization of the wastes by special mobile vehicles appeared as the most cost effective alternative.

However, when the unit and the operational costs of these systems are added to the collection route costs, the cost required for the mobile sterilization is found as very high. It is mainly due to the initial cost of the special sterilization vehicles including shredder, vehicle cost, special bins, etc. Therefore, the incineration of the health-care wastes that are collected from the European Side at the current incineration plant is more cost effective than applying a mobile sterilization system.

In the last scenario, it was assumed that all the district municipalities will be responsible for the collection of the health-care wastes generated from the clinics and other small health-care institutions in their regions. While the district municipality garages were accepted as the starting locations, the Kemerburgaz-Odayeri Health-Care Waste Incineration Plant was accepted as the finishing location. The results of the last scenario as the collection of the wastes generated from the small clinics are given in Table 4.7.

Table 4.7. The collection of the health-care wastes generated from the clinics by the district municipalities

Scenario 1 (District)	**Clinics (European Side)**
Vehicle number	21
Total time (Hour)	79.16
Load weight (kg)	5,142
Total cost (US $)	1,192
Cost (US $/kg)	0.230

After all the scenarios were evaluated, the cost of each scenario for the separate and together collections is presented in Table 4.8.

Some of the maps relating to the suggested scenario are given as an Appendix A and one example to these maps is presented in Figure 4.39. This figure shows the proposed route for the collection and transportation of the health-care wastes generated from the institutions in Sarıyer District. As it can be seen from the figure, like the other routes, the starting and final location for the vehicle of this route is Kemerburgaz-Odayeri Incineration Plant (which is represented with the red box). During the driving, the vehicle collects the health-care wastes from 17 institutions. While five of them are the hospitals, the rest consists of the clinics located at the Sarıyer District.

Table 4.8. Cost analysis of evaluated scenarios for separate and together collection

Number of the Scenarios	Separate Collection						Together Collection	
	Hospitals (US $)	**Hospitals (US $/kg)**	**Clinics (US $)**	**Clinics (US $/kg)**	**Total (US $)**	**Total (US $/kg)**	**Hospitals and Clinics (US $)**	**Hospitals and Clinics (US $/kg)**
First scenario	1,598	0.068	1,123	0.161	2,721	0.089	2.559	0.084
Second scenario	950	0.071	641	0.12	1,591	0.086	1,547	0.083
Third scenario	686	0.051	480	0.093	1,166	0.063	1,146	0.062
Fourth scenario	-	-	1,192	0.230	-	-	-	-

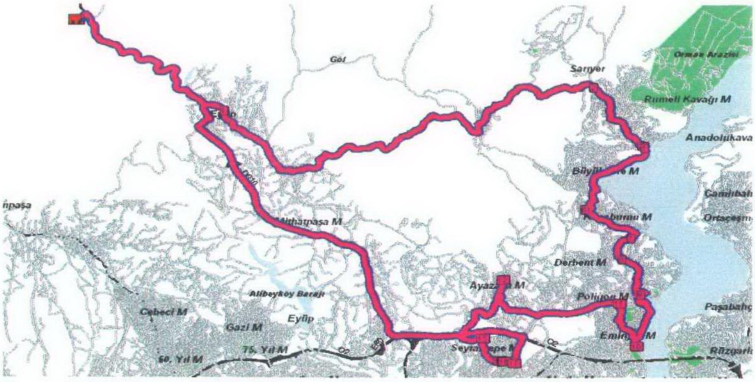


Figure 4.39. One of the proposed maps designed for the Sarıyer District for the transportation of the health-care waste.

4.7.1. Evaluation of the Suggested Waste Collection Network

When the Table 4.8 which is the evaluation of the all the scenarios is evaluated, it is found that the collection of the wastes generated from the clinics separately from the hospitals by the district municipalities is the most costly scenario than the others. While in the first scenario, total cost for the collection of the health-care wastes from all the clinics (both in the European and the Asian Sides of İstanbul) by the Metropolitan Municipality was 1,123 $ for 6,965 kg/day (Table 4.4), in the fourth scenario (Table 4.7), this costs was found as 1,192 $ for 5,142 kg/day. When these two scenarios were compared with respect to the cost spent per kg; the cost was 0.161 $/kg in the first scenario (Table 4.4) while it was 0.230 $/kg in the last one (Table 4.7).

The same situation was also observed in the comparison between the second and the fourth scenarios. As given in Table 4.5, the collection cost for the clinics was 641 $ for 5,142 kg/day at the European Side in the second scenario, whereas it was 1,123 $ in the fourth scenario (Table 4.7) for the same amount of waste.

After evaluating all the data gathered from the tables, it is revealed that collection of the health-care wastes generated from the hospitals and clinics together is the most appropriate solution rather than the collection separately in all scenarios. By collecting the wastes generated from the hospitals and clinics together, the number of vehicles and the distance taken is less thus leading to the reduction of the costs involved. As an example, when the wastes from the hospitals and clinics are collected separately as in the current situation, the total cost is 2,721 $/day for 30,274 kg/day and the required number of vehicles is found as 42. However if they are collected together, the cost decreases to 2,559 $/day and 40 vehicles are enough for the collection of all of these wastes.

As a conclusion, the separate collection of the health-care wastes at the European Side from the Asian Side, which was the second scenario, was suggested as the most cost effective solution. The benefit that may be achieved by reducing the transportation costs was of interest to the health-care institutions and municipalities at the micro level, and to the country at the macro level.

4.8. Results of the Alternative Treatment and Disposal Methods

Most of the alternative systems investigated represent new technologies and therefore, compared to incineration the reliability of these systems is questionable. The effectiveness of the disinfection must also be continuously confirmed by laboratory analysis. While they might initially appear to provide savings in terms of space and cost, this has to be balanced against their level of reliability, disinfecting capability, and support services offered by the equipment suppliers.

The problem with all these methods is that they can not be applied to all types of health-care wastes. This study indicates that health-care institutions can highly reduce the total costs for treatment and disposal of health-care wastes but in order to achieve this, the waste classification and segregation should be improved and then effective treatment methods described above should be employed based on the characteristics of the particular wastes.

When the generated health-care waste amounts at the European Side of İstanbul is considered, all these systems are found as very costly technologies. Among them, the mobile sterilization systems are found as the most costly technologies for the European Side of İstanbul. When the operational costs are compared, autoclave and microwave technologies are the other costly alternatives while the incineration cost is lower.

Since the waste generation at the Asian Side is less than the European Side, the construction of a new incineration plant or implementation of mobile sterilization system at the Asian Side will reduce the amount of incinerated health-care wastes at the Kemerburgaz Incineration Plant and its capacity will be enough for the future years.

4.9. Formulation of a Health-Care Waste Management Body

In the scope of this stage, the formulation and operation of a health-care waste management center is proposed. The center is accepted as the responsible for the operation of the health-care waste management plan (planning, establishment of the strategies, etc.). In formulation of the management structure, the responsibilities and authorities of the parties are clearly defined in order not to have any overlapping. In the proposed waste management structure, integration of small waste generation sources is also considered.

In the proposed structure, the Ministry of Environment and Forestry will be assigned by arrangement of the regulation and related legislation and the strategies and policies to be applied criteria for licensing. The Ministry of Health will also coordinate in the implementation of the regulation for the health-care wastes and the control of the health-care waste storage and disposal activities at the health-care institutions.

For the proposed institutional structure, firstly it is suggested that an autonomous center for the environmental management in Turkey should be established as a separate center at Ankara. It should be in close relation and cooperation with the Ministry of Environment and Forestry. The budget of this center should be provided by the

Government and also some portion of the income collected by the Municipalities should be transferred to this center.

This center will be responsible for all types of pollution as the air, water and soil pollution and all types of wastes including the solid, liquid and gases. For the better administration of these issues, there should be several departments in this Environmental Management Center as the Directorate of Solid Waste Management, the Directorate of the Waste Water Management and The Directorate for Air Pollution. The health-care wastes will be controlled by the Directorate of Solid Waste Management under the category of the Special Wastes and the unit responsible for these wastes will be the Health-Care Wastes Unit. The proposed institutional structure is given in Figure 4.40.

The proposed Health-Care Wastes Unit will be assigned the coordination of the activities between the Regional and Metropolitan Management Authorities. The main activities carried by the Health-Care Wastes Unit will be:

(a) evaluation of the management policies and alternative treatment technologies ,
(b) approval of the projects and programs prepared by the metropolitan cities, and
(c) control and inspections of the management practices in all the regions.

An annual auditing of the Health-Care Wastes Unit should be conducted by a professional audit team by An Autonomous Center for the Environmental Management.

After the Unit for the Health-Care Wastes is established, then the required number of personnel should be determined. This number should be determined according to the structure of the Health-Care Wastes Unit. As the main duty of this unit is control and inspection of the health-care wastes management practices in all over the Turkey, it is suggested that, the Health-Care Wastes Unit should be formed by six engineers for the control of the seven main regions of Turkey with respect to the estimated waste generation. These regions should be the Marmara, Black Sea, Mediterranean, Aegean, Middle, Southern and East Anatolian. Among them, Marmara Region should also be divided in three categories which are Southern Marmara, Thrace and İstanbul, Kocaeli and İzmit. For each regional division, one engineer should be assigned and each engineer will be responsible for the activities by the Metropolitan Cities within his responsibility area.

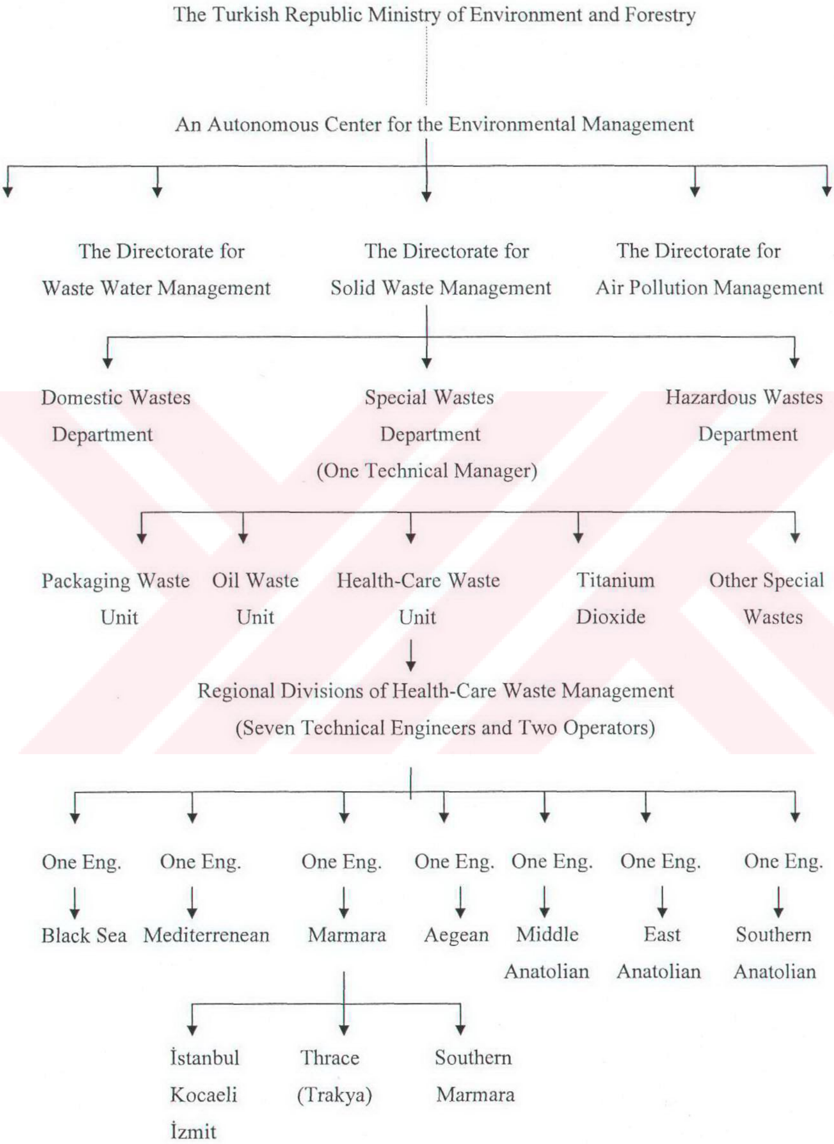


Figure 4.40. A proposed institutional structure for the health-care waste management.

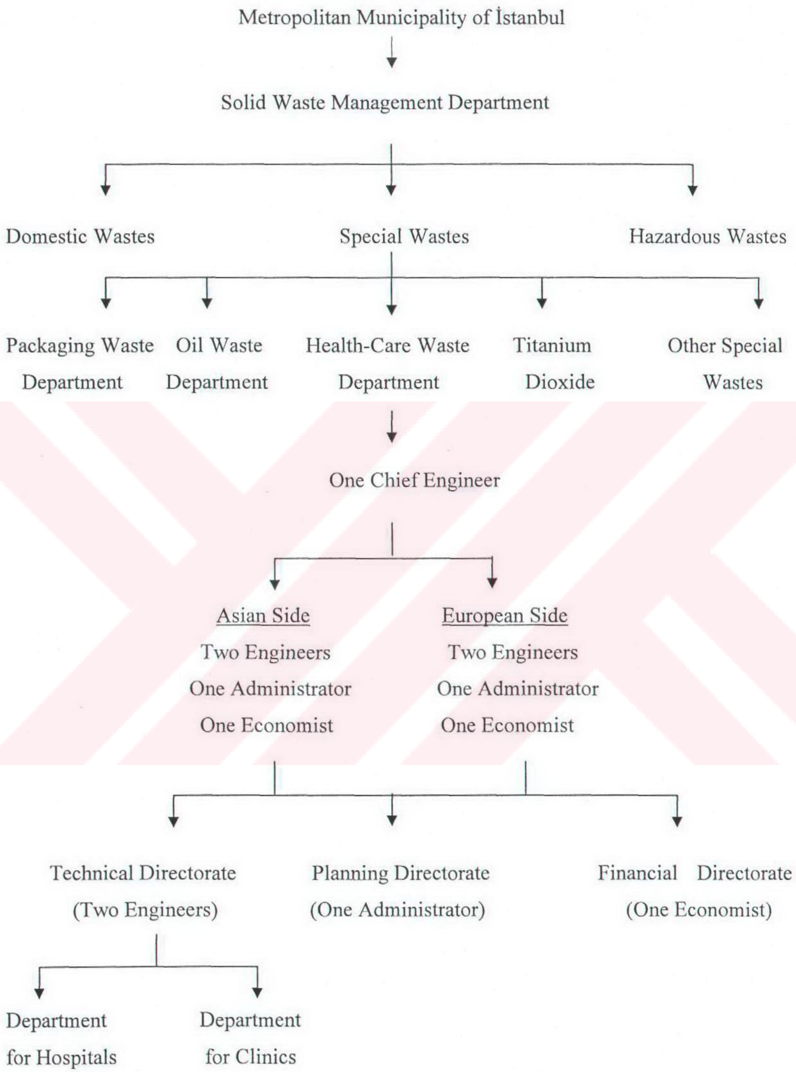
After this administrative structure is established, then the next step is the creation of a structure for the Metropolitan Cities. While the health-care wastes management at regions is controlled by the Regional Divisions, the health-care wastes management at the cities in these regions is managed by the Metropolitan Municipalities. According to the newly developed Regulation Plan of the Association of the Municipalities, the authority and the responsibilities for the management of the health-care wastes is given to the Municipality while the authority for the control of health-care wastes is carried on by the Governorship. Governorship can appoint one of its units which can be the Province Directorate for the Environment and Forestry, Province Directorate for the Health, etc. for this purpose.

A proposed institutional structure for the metropolitan municipalities is given in Figure 4.41. For the Health-Care Wastes Department which is proposed in the structure of the Metropolitan Municipality of İstanbul, the Asian and the European Sides should be evaluated separately. For each side, four people of whom two are engineers, one is operator and one is economists should be assigned for different directorates.

For the development of a new structure, firstly all health-care institutions should appoint their responsible personnel for the segregation and collection of the wastes and for the temporary storage room of the health-care wastes within the institution. Each institution has to inform the names of these personnel to the authorities and the names of these personnel should be kept as a list by the technical engineer of the Municipality. This will help carrying on the operations more systematically.

The Health-Care Waste Department of the Metropolitan Municipality will be consisting of three main directorates administrated by a general manager. The general manager will be responsible for the overall control and auditing of these three directorates for the two sides of İstanbul.

The first one will be the Technical Directorate administrated by two engineers. The collection of the health-care wastes from the institutions, the transportation of these wastes to the final disposal area and the incineration or landfilling of the wastes will be carried on and controlled by these engineers. The treatment of the health-care wastes in the incineration plant should be conducted and monitored.



Figuure 4.41. A proposed institutional structure for the Metropolitan Municipalities.

In this Directorate, the assignments for hospitals and small clinics separately will lead to an efficient and reliable record keeping for each institution. Therefore, one engineer will be responsible for the health-care wastes at the hospitals, while the other one is responsible the ones at the clinics. The collection of the domestic and recyclable wastes from the institutions will also be monitored as well as the health-care wastes. They should also control and conduct the recycling processes for the collected recyclable materials generated from the health-care institutions.

The second directorate is the Planning Directorate. It is administrated by an operator. This Directorate should be responsible for training of the personnel involved in the health-care waste management. The main duties of the Technical Directorate are:

(a) determination of the general management policies,
(b) organizing training programmes for the health-care institutions,
(c) coordination of activities with the institutions, and
(d) coordination of the responsible people of their region.

For an efficient record keeping for the health-care wastes, the Planning Directorate should also prepare the necessary documentation including the quantities and characteristics of waste, date of collection, name of the personnel, etc. This documentation should be provided for the waste collecting personnel of the Technical Department and they should be filled by the health-care waste responsible personnel and the related people of the institutions. An example of this documentation is given in Appendix B.

The third directorate should be the Financial Directorate that will be responsible for the financial situations and administrated by a preferably economist as a finance expert. In this Directorate, the inventory keeping for the quantities of waste collected, the following up of the forms, preparation of the statistical information will be accomplished. The penalties should be given to the violators of the Regulation and the income from these penalties and the income from the certificates will be used in the management of the health-care wastes. A small part of these incomes should be transferred to the Autonomous Center at Ankara.

In this stage, the number of vehicles and the equipment owned by the metropolitan municipality will also be identified and the metropolitan municipality will make any new investments in these items if it is required. Also the required expenditures and supplement of the necessary equipment to the institutions including the red bags, sharp boxes, etc. will be managed by the Financial Directorate.

According to the proposed routes for the European Side of İstanbul (Table 4.7.2), the required number of the vehicles for daily collection is found as 25. Therefore for these vehicles, 25 drivers will be required within these units. There should also be 25 assistant personnel for the collection of the health-care wastes.

According to the field research conducted at the European Side of İstanbul, it is observed that 60 per cent of the budget is spent for the personnel salaries. Therefore minimum employees and regarding salaries should be arranged in comparison with the required assignments. After the evaluation of the existing situations, the optimum salaries for an engineer, an administrator and an economist are found as 700 \$, 600 \$ and 500 \$, respectively. The salaries for the vehicle driver is 550 \$ and for the assistant personnel is 400 \$. For the case that the vehicle driver is not government officer, this salary can reach to 1000 \$.

The wrong organizational structure and the inefficient management of the resources leaded to an insufficient management of the health-care wastes at the European Side of İstanbul. With the implementation of the institutional structure proposed in this study, health-care waste management at the European Side as well as the Asian Side can be systematically carried on and can be regularly controlled. This structure will help the correct classification and appropriate segregation of the wastes by the responsible personnel in addition to efficient disposal activities. Designation of such structure will also attract the public attention to the management of health-care wastes and the awareness will be improved.

5. SUMMARY AND CONCLUSION

In this study, the management of the health-care wastes at the European Side of İstanbul was analyzed from the point of view of the existing management practices including the classification, segregation, minimization and on-site storage of the health-care wastes by the health-care institutions and the collection, transportation and final disposal of these wastes by the İstanbul Metropolitan Municipality. Although the Turkish Medical Waste Control Regulation of the Ministry of Environment and Forestry was published at May 20th, 1993, because of the inadequate implementation of the Regulation, health-care wastes still have been a problem for the İstanbul city of Turkey.

When the existing situation is evaluated, it is found out that the Turkish Medical Waste Control Regulation has insufficient content for an efficient health-care waste management both at the institutional and administrative level which needs a significant revision. In the evaluation of the existing situation, the unconsciousness of the authorities and the personnel of the health-care institutions about the adverse effects of the health-care wastes, lack of policies and strategies which have resulted in inadequate management of these wastes are also observed. As the top management in most of the health-care institutions are not aware of the legal requirements about the health-care wastes, the importance of training for both the top management people and at the personnel must provided at the frequent periods.

Proper segregation of the health-care wastes is the main stage for minimizing the risks both in and outside of the healthcare institutions. With the illustrated pictures from the institutions, it is presented that there is almost no segregation activities for the domestic, recyclable and health-care wastes in most of the health-care institutions. The segregation of the health-care wastes such as infectious, pathological, radioactive wastes and sharps is not also accomplished. This situation was especially observed in state and social insurance institutions which have limited budget for these services. In addition to the segregation practices, the next issue observed is the usage of the inappropriate bags, containers and transportation carts within the institutions. The disinfection and sterilization of these vehicles are conducted even worse.

In the scope of the field research, wrong handling practices of the collection and storage stages of these wastes were also observed. It is often the case for the patients, visitors and personnel to be infected by these wastes in many institutions. With the other wrong applications, the conditions of the temporary storage rooms also indicate the health-care waste management problems at the institutions.

To overcome all these problems identified, the necessary suggestions and recommendations were presented in the Results and Evaluation Chapter. The main priorities for the safe handling and transporting of the health-care wastes (waste characterization, safe collection, segregation, packaging etc.) are developed by taking into account both environmental and economic factors. With the efficient implementation of these suggestions, the appropriate management systems for the health-care wastes would be realized significantly at the European Side of İstanbul.

Among these sound managerial approaches, the most important stage is the evaluation of waste minimization and reduction techniques. After the evaluation of the data obtained from the field research, as the most waste generating districts, Şişli, Fatih, Bahçelievler, Bakırköy, Beyoğlu and Gaziosmanpaşa were suggested as the pilot areas to be selected for the waste minimization activities. The state and private hospitals are also recommended as the pilot institutions. The main waste generating unit is found as the patient services with the 84 per cent in comparison with the laboratories and support services. According to generated quantities, the main types of the health-care wastes that should be minimized initially are determined as the domestic, infectious, recyclable and pathological wastes and sharps respectively.

By the proposed training of the waste handling people, the segregation of the wastes and the cost reduction arisen from the health-care waste management systems are realized much more efficiently. According to the estimations, in the first year of the application of the waste minimization practices in the European Side, the amount of the infected wastes will be reduced drastically (at least 50 per cent). The 50 per cent volume reduction of these wastes will lead the significant reduction on the collection, transportation and eventually the final disposal and treatment cost. By the 50 per cent minimization in the generated waste quantity, also the life of the existing incineration plant will be increased.

The results obtained at the end of the laboratory analysis of the health-care wastes are also accepted as an indicator of the inefficient waste management practices at the health-care institutions too. The results of the analyses showed that many infectious microorganisms were present in the health-care waste samples. It is because of the long detention time in the units and at the temporary waste storage rooms of the health-care institutions. At the end of the analyses, the reproduction of the microorganisms causing several infections was found as considerably much in comparison with the value from the literature. Therefore, it is inevitable to be exposed to a several diseases resulting from these organisms.

Within the scope of the study, the problem of optimally routing and scheduling of the collection of the health-care wastes from the health-care institutions was tried to be solved by the development of alternative collection and transportation scenarios given in Chapter 4.7. These scenarios were created for the separate and together collection of the wastes of the hospitals and clinics along with the different disposal systems.

When the existing situation and all the scenarios developed are taken into consideration, the collection of the health-care wastes at the European Side separately from the Asian Side is suggested as the most cost effective solution. It is also revealed that the collection of the health-care wastes generated from the hospitals and clinics together is the most appropriate solution rather than the collection separately in all scenarios. In this situation, the number of vehicles and the distance taken is less thus leading to the reduction of the costs involved.

By the application of this routing system and the implementation of the waste minimization suggestions, more than 40 per cent reduction in the cost arisen from the transportation of these wastes will be accomplished. The benefit that may be achieved by reducing the costs arisen from the handling and management of the health-care wastes is of interest to the health-care institutions and municipalities at the micro level, and to the country at the macro level.

Within the scope of the study, the possible alternatives including the mobile and stationery systems for the treatment and disposal of the health-care wastes including the autoclaves, microwaving, chemical disinfection, etc. are also evaluated. At the end of this stage, it is decided that, to determine the best effective treatment systems according to the type of wastes, firstly an effective waste segregation practices must be ensured. When the generated health-care waste amounts for the European Side of İstanbul is considered, all these systems are found as very costly technologies. Therefore, since the waste generation at the Asian Side is less than the European Side, the construction of a new incineration plant or implementation of mobile sterilization system at the Asian Side will reduce the amount of incinerated health-care wastes at the Kemerburgaz-Odayeri Incineration Plant and thus increase the usage of the plant. Therefore, it is better that the existing incinerator at Kemerburgaz-Odayeri should continue its operation for the European Side of İstanbul.

The wrong institutional structure and the inefficient management of the resources leaded to an insufficient management of the health-care wastes at the European Side of İstanbul. With the implementation of the institutional structure proposed in this study, health-care waste management can be systematically carried on and can be regularly controlled. This structure will help the correct classification and appropriate segregation of the wastes as well as the efficient disposal activities by the responsible health-care waste personnel. Designation of such structure will also attract the public attention to the management of health-care wastes and the awareness will be improved.

As a conclusion, in this study, health-care waste management is analyzed from a wide variety of considerations. During the conducted stages, optimization of the health-care waste management systems is tried to be obtained. The proposed suggestions, recommendations, graphs, tables and maps about the study are given in text. Thus, the appropriate management alternatives for these wastes at the European Side of İstanbul are promoted.

It is believed that this exhaustive study is the first scientific approach for the solution of the health-care waste management at the European Side of İstanbul.

6. RECOMMENDATIONS FOR FURTHER STUDIES

This study was an existing situation evaluation research and it was planned with the aim of development an integrated health-care waste management plan for the European Side of İstanbul. The following topics given below are recommended for further studies:

(a) implementation of the proposed health-care waste management plan in the other metropolitan cities of Turkey like İzmir, Ankara, etc.,

(b) investigation of the amount and potential recycling and recovery of the dental wastes generated at the dental health-care institutions,

(c) analysis of recycling potential of the health-care wastes and evaluation of the waste minimization technologies conducted on a single pilot hospital, and

(d) the investigation and application of the small individual mobile treatment and disposal methods within the selected pilot health-care institutions and the cost benefit analysis of this application.

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http://www.inda.org/enduses/hlthbro/toc.html#contents

APPENDIX A

The Maps for the Proposed Collection and Transportation Routes

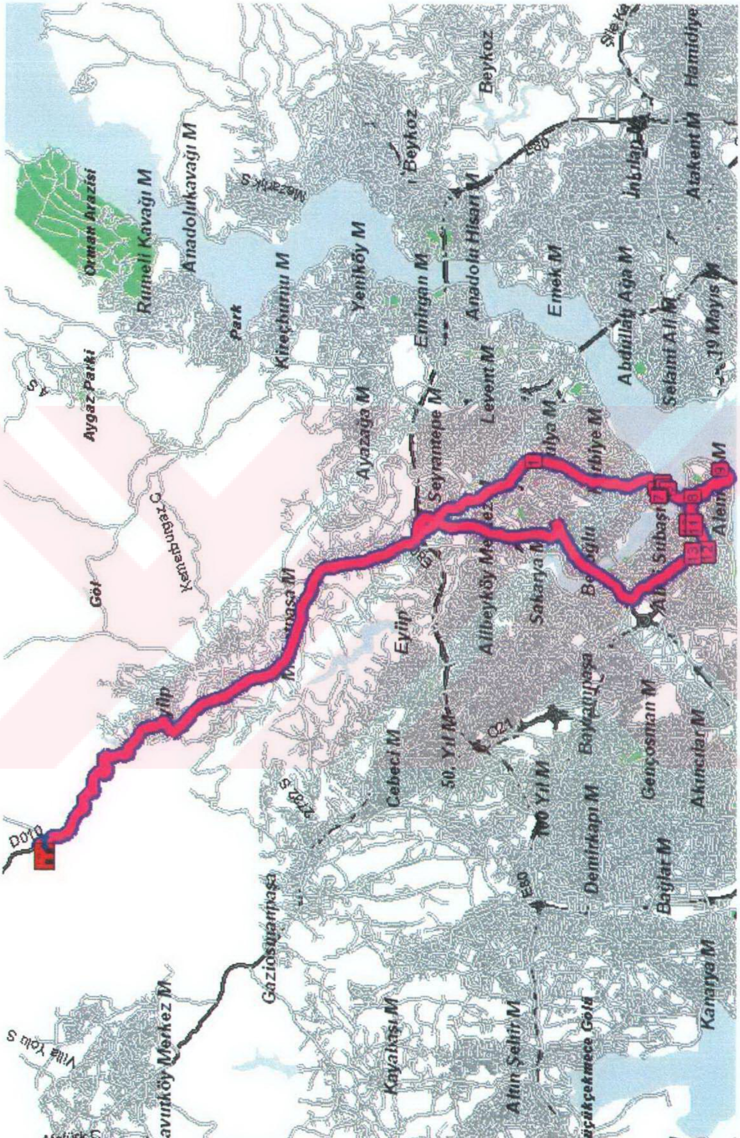

Figure A.1. The proposed route map for the Eminönü District.

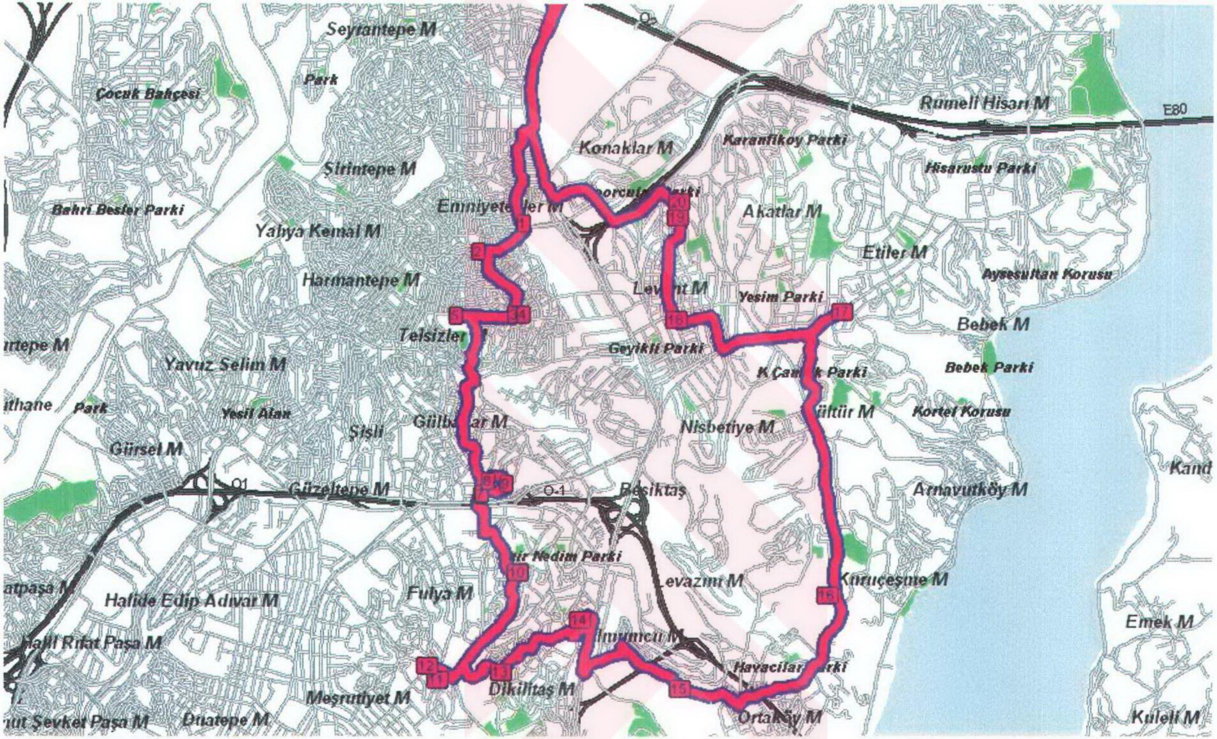

Figure A.2. The proposed route map for the Mecidiyeköy, Beşiktaş and Levent Districts.

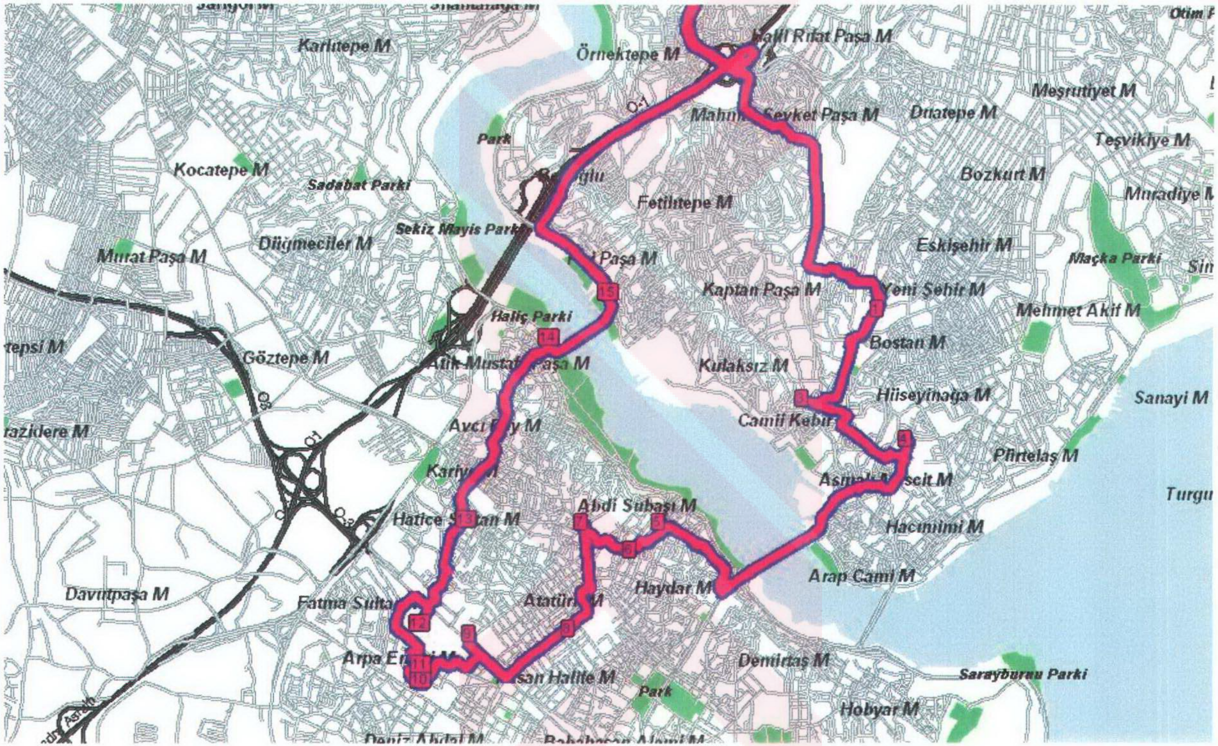

Figure A.3. The proposed route map for the Beyoğlu and Kasımpaşa Districts.

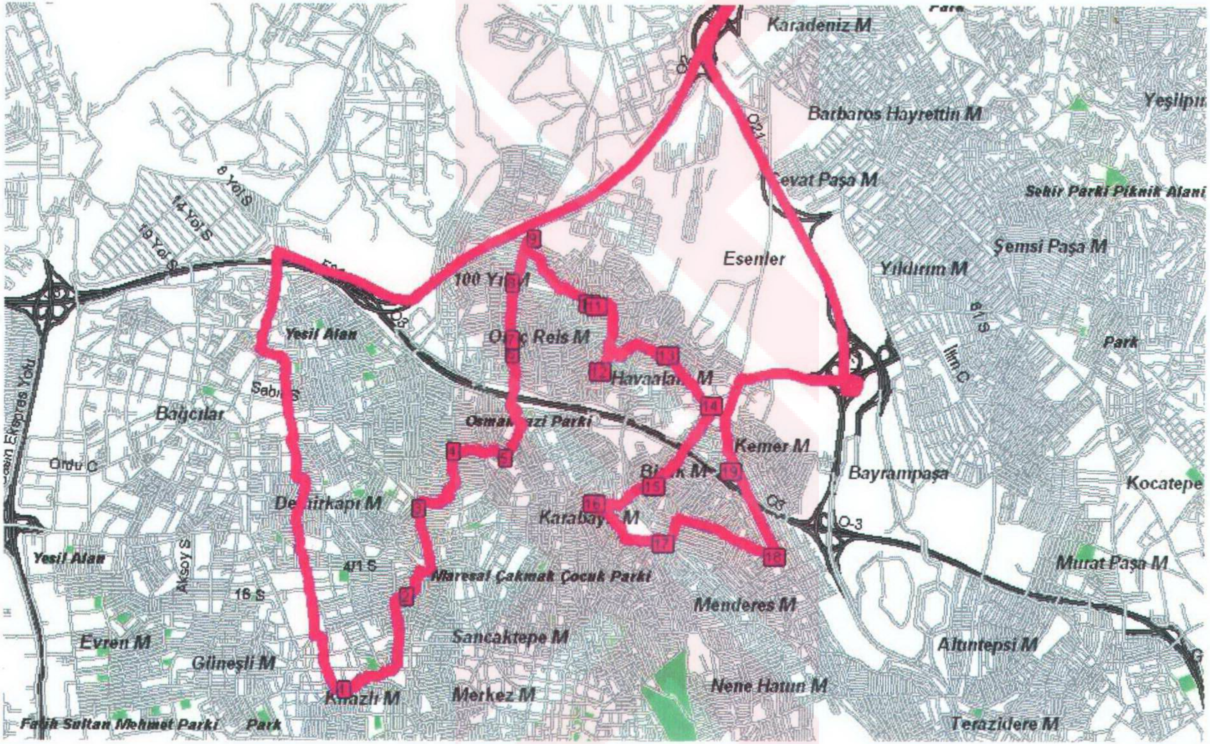

Figure A.4. The proposed route map for the Çapa, Esenler and Atışalanı Districts.

APPENDIX B

Following-up Form for the Health-Care Wastes

APPENDIX B

<table>
<tr><td colspan="4">A. WASTE SOURCE</td></tr>
<tr><td>The name, address and phone number of the institutions</td><td>Date</td><td>Amount of delivered waste (kg) :
Number of waste bags:</td><td></td></tr>
<tr><td></td><td colspan="3">Main considerations</td></tr>
<tr><td>Waste characteristics</td><td colspan="3">Accident faced during the storage of the wastes and taken precautions:</td></tr>
<tr><td>( ) Infectious
( ) Toxic
( ) Sharps
( ) Sensitive to shocks
( ) Give reaction with water
( ) Give reaction easily
( ) Radioactive</td><td colspan="2">Responsible personnel of the institutions:</td><td>Responsible personnel of the technical department:</td></tr>
<tr><td colspan="4">B. TRANSPORTATION</td></tr>
<tr><td>Name, addressee and phone number of the transportation company:</td><td colspan="3">License plate of the vehicle:
The brand and model of the vehicle:
The units of which the wastes are collected:
1- 3-
2- 4-</td></tr>
<tr><td>Accident faced during the transportation and taken precautions:</td><td colspan="2">The name of the disposal plant that the wastes delivered:</td><td>Name and the title of the person received the delivery:</td></tr>
<tr><td colspan="4">C. DISPOSAL PLANT</td></tr>
<tr><td>The name of the final disposal dlant:</td><td colspan="3">The place buried (if burying is applied):
The disposal methods and place for ash and other remaining (if incineration is applied):</td></tr>
<tr><td>Method of Disposal:
( ) Landfilling
( ) Incineration
( ) Other (explain)</td><td colspan="2">The Amount Waste
Number of Bags /kg
Date of Disposal</td><td>Name and the Title of the responsible person:</td></tr>
</table>

The date of the delivery of the document to the Local Management Center: ....

The name of the personnel received the document: ....

Figure B.1. The form for the following up of the health-care wastes (Ministry of Environment and Forestry of Turkey, 1993).